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a formula for Styling Acceptance

BASED ON TALK* BY

Raymond Loewy

Raymond Loewy Associates

HOW far ahead can the designer go stylewise? This is the all-important question, the key to success or failure of a product. Its satisfactory solution calls for an understanding of the tastes of the American consumer.

We automobile designers are realists; we like to deal in facts. Here, however, there are no yardsticks, no ways to chart a curve of public reaction to advanced design. Nevertheless there are a few reasonably well established facts among all these variables, and they can help us in our thinking. Being an engineer at heart I have tried to introduce some order into this confused morass of human aesthetic behavior . . . in simpler terms, design acceptance.

As a first groping effort in this direction you might like to hear our ideas on the subject at Raymond Loewy Associates. Bear in mind that the conclusions are empirical, and that I speak of manufactured products in general and not only automobiles:

1. Mass production of a successful given product by a reputable company over a period of time tends to establish the appearance of this particular item as the NORM in its own field. (The public more or less accepts it as the standard for "looks" or styling.)

2. Any design that departs abruptly from this NORM involves a variable risk to its manufacturer. (We shall analyze the character of this risk later on; it has both positive and negative aspects.)

3. The risk increases as the square[1] of the design gap between NORM and advanced model in the case of a large manufacturer. (In plainer language, a little style goes a long way.)

4. The risk increases as the cube of the design gap in the case of a smaller manufacturer or an independent manufacturer. (It is more difficult for these to establish a NORM because they cannot blanket the nation with automobiles in their design style.)

5. If the small manufacturer or the independent succeeds in establishing a NORM of its own, he may lead the large manufacturer to widen the design gap with that manufacturer's next models to establish a new and different NORM. Or, on the contrary, the large manufacturer may retaliate by reducing the gap to reaffirm forcefully the validity of its own NORM. He usually carries the field through sheer weight of mass manufacture.

6. The consumer is influenced in his choice of styling by two opposing factors: (a) the attraction to the new, and (b) the resistance to the unfamiliar. As Kettering said, "People are very open-minded about new things—so long as they are exactly like the old ones."

7. When resistance to the unfamiliar reaches the threshold of a shock zone and resistance to buying sets in, the design in question has reached its MAYA stage—Most Advanced Yet Acceptable stage.

8. We might say that a product has reached the MAYA stage when 30% (to pick an arbitrary figure) or more of the consumers express a negative reaction to acceptance.

9. If the design seems too radical to the consumer, he resists it whether the design is a masterpiece or not. In other words, the intrinsic value of the design cannot overcome resistance to its radicality at the MAYA stage.

There are some constants in the problem:

a. The Teen Age group is the most receptive to advanced ideas.

b. Two unmarried individuals each having high MAYA coefficients have a lower common coefficient as soon as they marry. (In other words, their collective tastes become more orthodox.)

c. The older age groups are influenced increasingly by the style opinion of the Teen Age group. (This process is accelerating.)

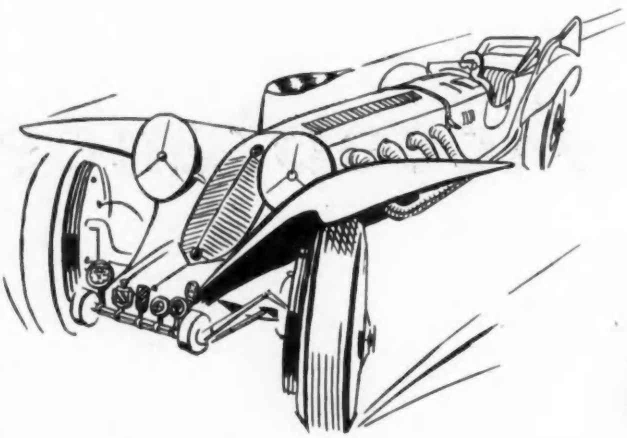
d. Women are often the deciding factor at the time of purchase. Her influence decreases in direct

[1] The use of mathematical symbols—such as the cube and square root—does not pretend to be accurate. The terms are used figuratively to express a relationship which cannot be measured.

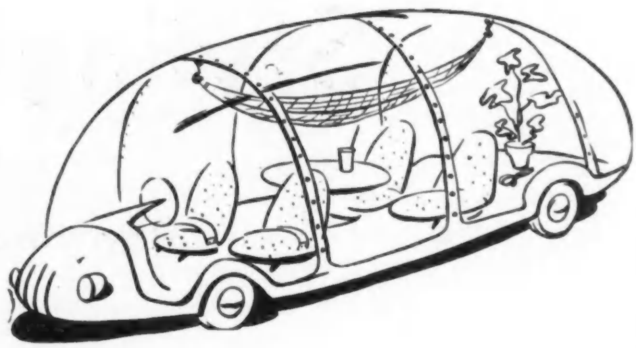
* Talk, "The Maya State and Consumer Acceptance," was presented at SAE Annual Meeting, Detroit, Jan. 12, 1950.

Advanced . . . . But Acceptable?

"There ought to be a car with . . ." has been popular automobile talk fare down through the years. The car stylist is flooded with such ideas—some reasonable, but many impractical. The more extreme ones take on the shapes shown here.

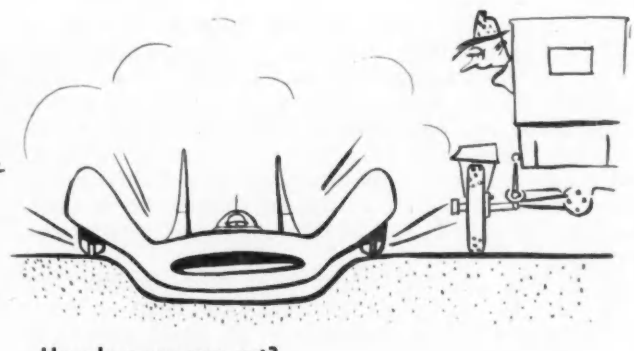


The Diehard's Dream

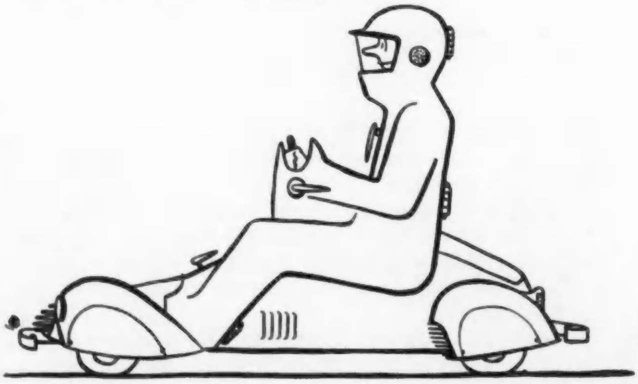


The All-Plastic Top

"Quick, Henry, the garage stretcher!"



How low can you get?



Functional Special

Functional Special (Convertible)

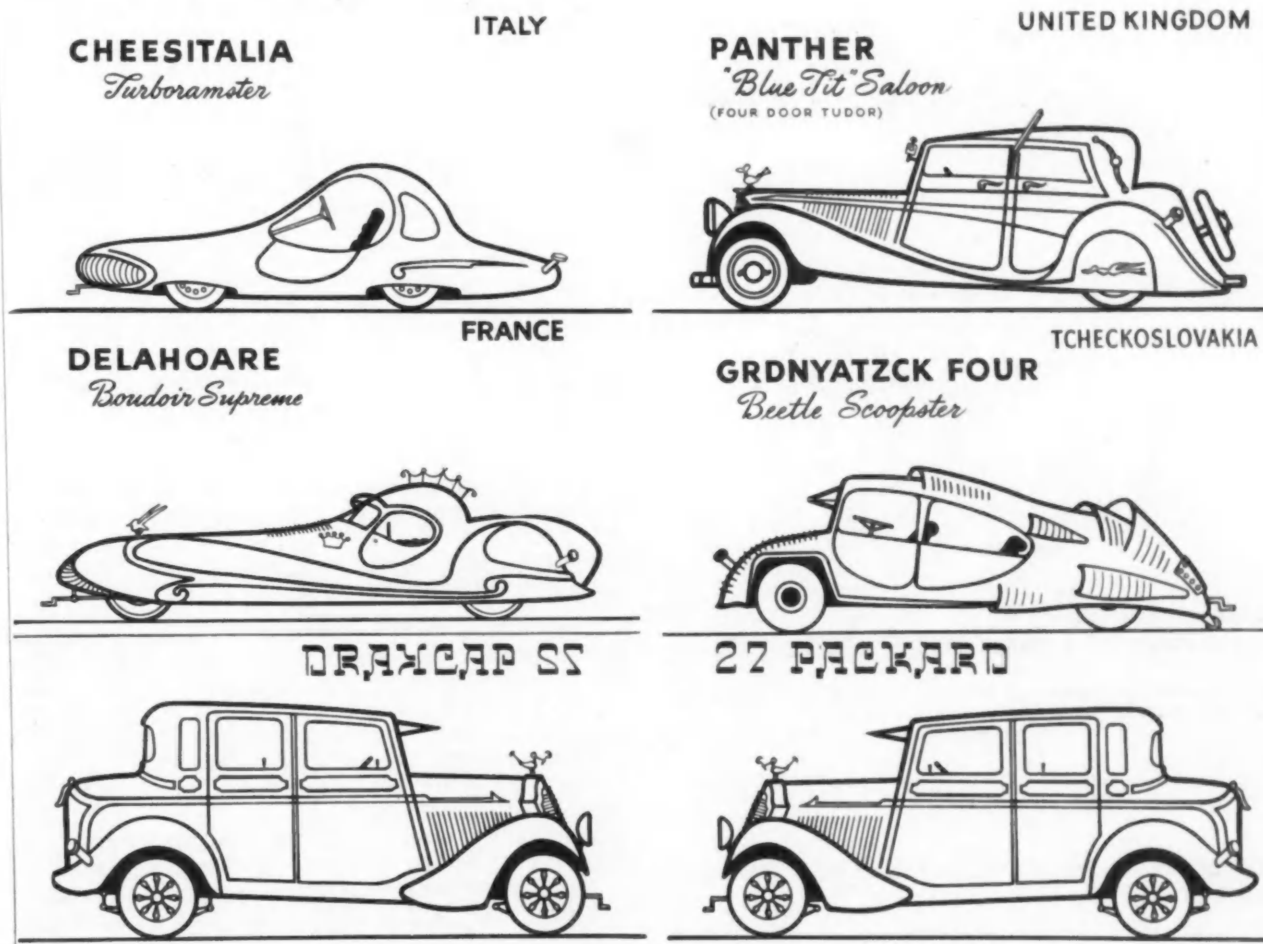
proportion to the length of the marriage, reaches a plateau and then reverses itself in later years.

e. The MAYA stage varies according to topography, climate, season, level of income, and so forth. (For instance, an advanced design sells better in Texas than in North Dakota. Dark color is more popular in Pennsylvania than in Texas. A radical design will find good acceptance in larger cities, university towns, resorts; poor acceptance in mining towns, the farm belt, and so forth.)

In summary, let us say that any advanced design involves risk to the manufacturer. I believe there is

Examining the Competition Before Design

We always look at the foreign competition from the design standpoint to see if there is anything going on that we ought to know about. After a study, we usually don't borrow many of the features and the picture is not too helpful. American tastes are a little different.



no alternate between taking some degree of such risk, or slow but certain eventual disappearance of the firm.

The smart manufacturer seems to be the one who is willing to take what Gen. Eisenhower calls a "calculated risk." The theory expressed above, however empiric, may assist him in his calculation.

What does RISK mean? There are as many definitions of it as there are persons. Our own thinking is somewhat as follows:

First, a large and successful corporation can get along year after year without taking more than a minimum of calculated risk. Its own NORM acts as a style flywheel. This balance can be maintained until an equally heavyweight corporation succeeds in establishing its NORM along different lines.

Second, a smaller or independent manufacturer may survive for considerable time on the basis of minimum risk so long as he follows the accepted style NORM closely as it has been established by the leading manufacturer. But the company will not progress and forge ahead. A case of pernicious sales anemia sets in, resulting in eventual extermination.

Third, assuming that quality, engineering and price are correct, calculated risk is the open gate to improved business for the smaller manufacturer. It is the key to successful operation and business expansion.

Fourth, the calculated risk should be such that it never takes the design beyond the MAYA stage.

Fifth, there are reasonably accurate ways and means of pre-ascertaining the MAYA level of a given product in a given consumer's climate. This "climate" refers to: the State, location in the State, income, local characteristics, and so forth.

This discussion, tentative as it may be, has some value. At Raymond Loewy Associates we have made good use of it in the design of thousands of products, packages, structures, and so forth, for more than a hundred corporations.

Soil-Vehicle Found

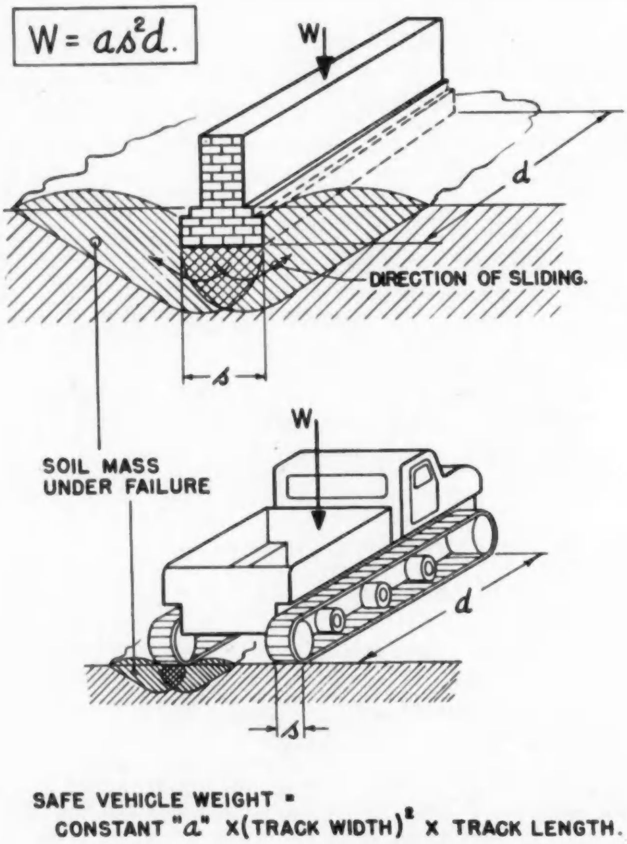


Fig. 1—Formula for determining bearing capacity of soil under a wall is equally effective in finding bearing capacity under tracks of a vehicle

(This paper will be printed in full in SAE Quarterly Transactions.)

STUDIES in soil-vehicle relationships reveal that present concepts are inadequate. Not only have they proved to be inaccurate, but they leave a pessimistic picture on the outlook for improved vehicle mobility.

Typical of the misconceptions which may lead to false solutions is the "ground pressure" design methods. Some general fundamentals during the last 40 years in both soil mechanics and civil engineering, which show this concept to be misleading, can be applied to vehicle design.

For example, take the bearing capacity of soil which is able to support the foundation of a long brick wall. Such a wall is shown in Fig. 1. By "bearing capacity" of the soil is meant such safe weight W of the brick wall as can be supported by the ground without failure. Soil under failure slides upwards, as shown by the arrows, while the whole mass marked by the heavily hatched section moves outwards. The wall then sinks down, causing damage to its structure.

Civil engineers have several formulas for determining the safe wall weight W which can be supported by a given soil. One of the typical formulas of this nature as applied to sandy soils would be as follows:

$$W = a \times s^2 \times d$$

where:

- a = a certain constant which may be determined once and for all by experiment or by computation,
- d = the length of the wall, and
- s = the width of its foundation.

It is obvious that the track of a vehicle may cause the same type of ground failure as that caused by the foundation under consideration. Such a condition is shown in the lower part of Fig. 1. In this case the formula for the safe vehicle weight, just short of sinkage, would read as follows:

Safe Vehicle Weight = Constant "a" × (Track Width)^2 × Track Length

Suppose we now assume an imaginary but perhaps typical design problem. A cargo carrier shown in Fig. 2 weighs 6000 lb and has a ground contact area for each track of 75 by 21 in. Upon completion of the design and testing, it develops that the payload is too small to meet user requirements. An increase of 30% is required, thus raising the gross weight to 7800 lb.

User and designer talk over the problem and agree that the "ground pressure" should be kept constant. Therefore, they say, to meet the higher load requirement, either the track length or track width should be increased by 30%.

After sketching the revised vehicle, the designer finds that a track wider by 30%, or increased to a width of 27 in., would increase intolerably the total vehicle width, or would require a complete redesign of the suspension and frame to avoid this disadvantage (See upper right corner of Fig. 2.) It appeared necessary, therefore, to increase the track length 30% by lowering of the idler to the ground and providing it with springs. This proved to be admissible, although some fears of endangering the steering characteristics of the vehicle were entertained.

The revised conception of the vehicle is sketched directly below the sketch of the original 6000 lb tractor. It will be noted that by increasing the

EXCERPTS FROM PAPER* BY

Major M. G. Bekker

Department of National Defence
Canada

Concepts Impeding Design

ground contact length to approximately 100 in. and by preserving the same track width and gross weight of 7800 lb, the revised vehicle exerts the same ground pressure as the 6000-lb vehicle did—1.9 psi. Both user and designer are satisfied, since the original requirement of low ground pressure has been maintained.

The reasoning applied, however, was in error, since the change in design from 6000 to 7800 lb gross weight could have been accomplished under given conditions much more simply. The reasoning was faulty because it was based on the erroneous assumption that vehicle performance is tied to the idea of low "ground pressure."

The formula says that the safe load does not depend on the ground pressure, but on the factor $a \times s^2 \times d$.

Therefore the width "s" of the track did not need to be increased by 30% to maintain the safe loading. Widening the track by the square root of the desired 30% increase would have been quite sufficient, because "s" enters the formula in the second power. The bearing capacity of such a track under 7800 lb loading would then be the same as the bearing capacity of the old track under 6000 lb.

In other words, the apparent need for a track width of 27 in. was based on an error. A 24-in. wide track would have been adequate, because the required increase is not 30% but only 11.5%. Furthermore, the 24-in. track could probably be accommodated without any change in vehicle design. And the whole alteration could have been accomplished by making a new set of tracks, instead of changing the suspension design and endangering the steering characteristics of the vehicle.

This example shows how the "ground pressure" concept may lead to false solutions. The formula explains why so many experiments based on that principle have failed to show the true picture of this facet of the vehicle-to-soil relationship.

Stress should be placed upon the fact that the "ground pressure" criterion is inadequate because it embraces only the factor of area upon which the load is acting. For a true evaluation of any specific

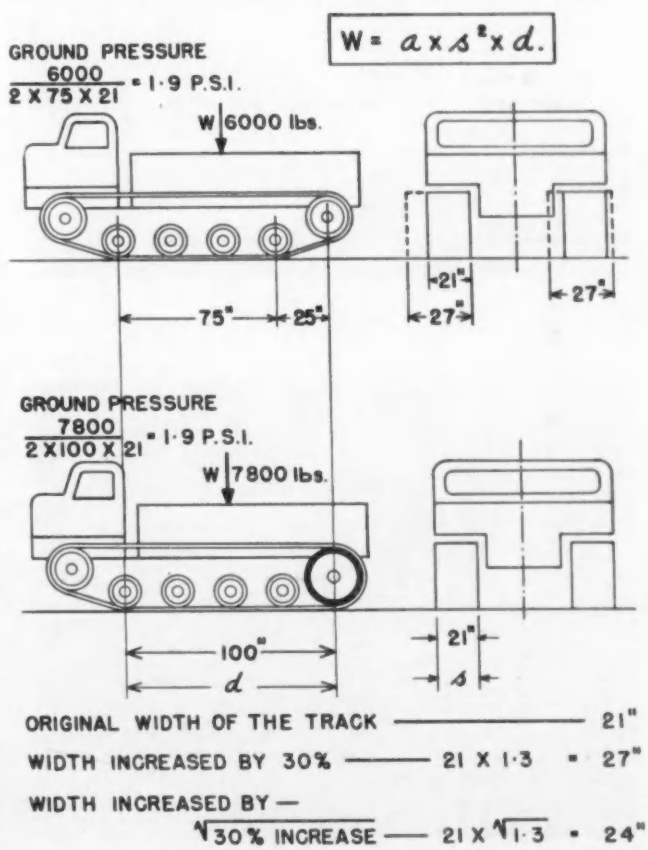
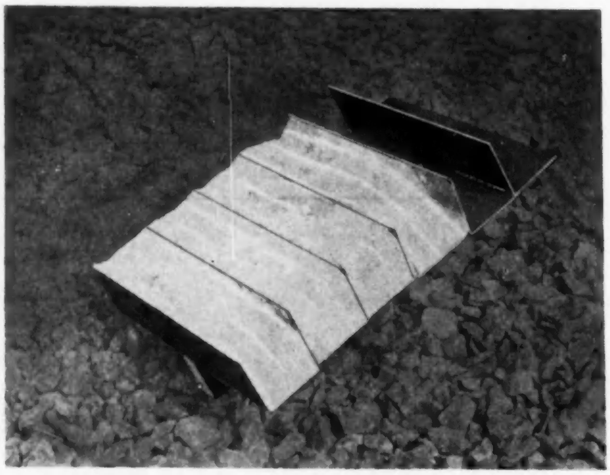


Fig. 2—By the ground pressure concept, changing the weight of this cargo carrier from 6000 to 7800 lb calls for a track width increase from 21 to 27 in. Since this could not be accommodated without extensive redesign, track length was increased from 75 to 100 in. A soil mechanics formula used by civil engineers reveals that switching to only a 24-in. track would do the trick, without any further redesign

* Paper "Relationship Between Soil and a Vehicle," was presented at SAE Annual Meeting, Detroit, Jan. 10, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)



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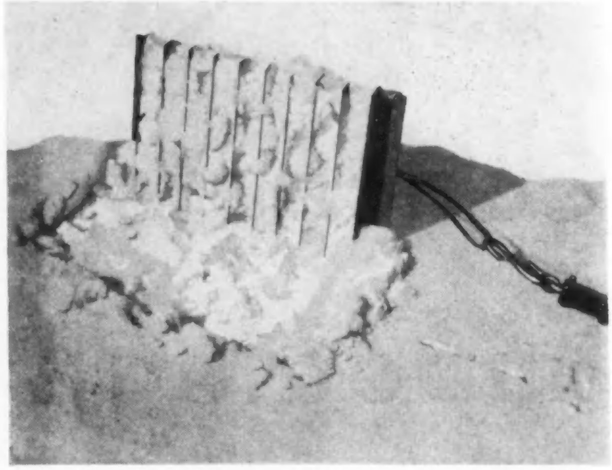

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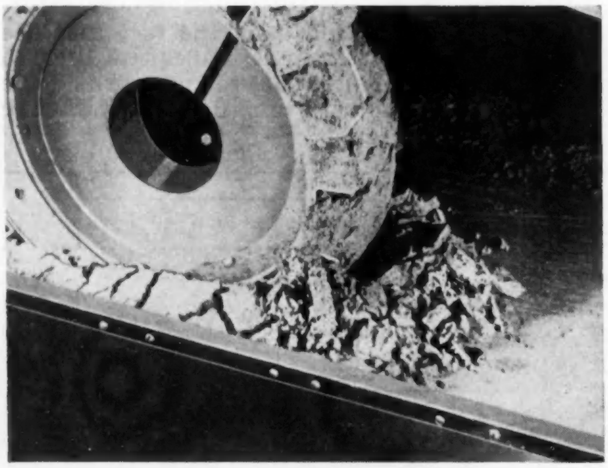

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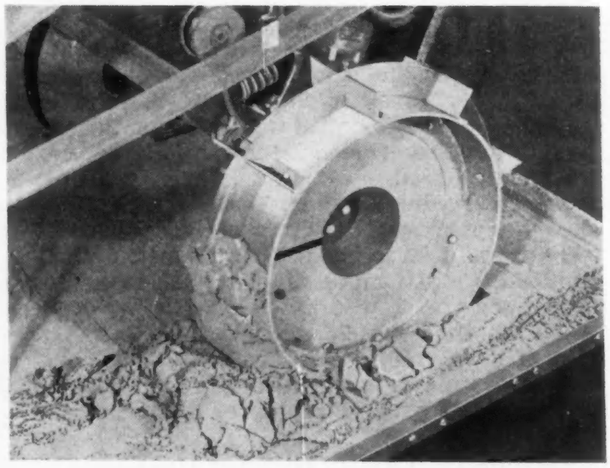

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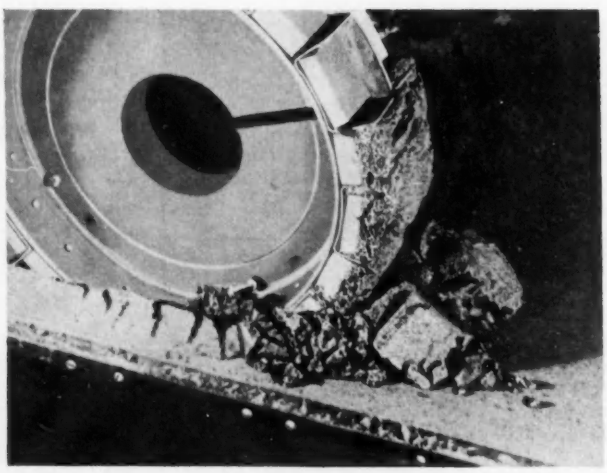

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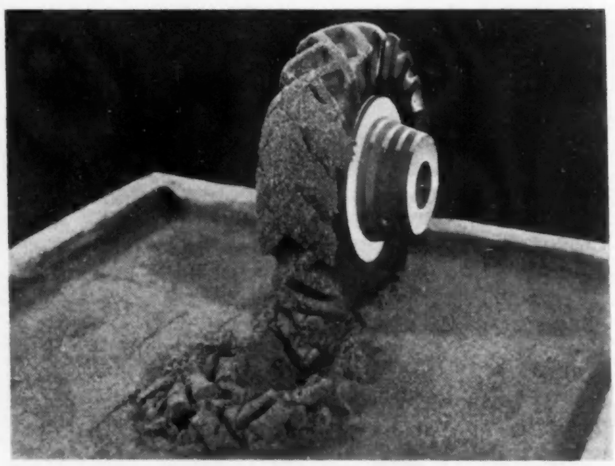


F

Fig. 3—Tests show that grousers do little toward enhancing tractive effort. "A" shows how spaces between grousers fill with soil. "B" reveals that the same thing happens in snow. Soil packed itself between the twelve grousers on the wheel in "C." Reducing the number of grousers to nine in "D" doesn't change the condition. Shortening the grouser height from 2 to 1 in. in "E" makes no difference either. Even rubber tires, as shown in "F," fall victim to soil-packing, which always takes place at the ground contact area without any regard to the "self-cleaning" properties of the grousers

soil failure under vehicle action, the inclusion of the form and shape of that area is essential.

Work undertaken within this concept led to an almost paradoxical experience. One of the experimental vehicles exerting about 2 psi of "ground pressure" gave an outstanding performance in swamps and heavy soils in which a standard type vehicle, with a ground pressure of 1.2 psi, failed completely.

Similar conclusions may be drawn in respect to the problem of snow-crossing vehicles; but in this case there are many additional factors which make the "ground pressure" formula even more misleading.

Here is another fact-of-life in soil-vehicle relationships that runs contrary to conventionally accepted thinking: The dimensions, shape, and number of grousers on a conventional track or treads on a tire have, theoretically, no bearing on tractive effort. This is because the spaces between the spuds fill up with soil which then slides over the stationary soil mass. Thus, in the final analysis, instead of so-called "grouser action," one has a prism or block of soil moving on soil.

These phenomena may be reproduced experimentally, as ilustrated in Fig. 3. Fig. 3A shows the discussed soil block associated with a track negotiating average soil. It may be clearly seen that the spaces between grousers have been completely filled with soil, and that this soil will move with the track.

Fig. 3B shows the same condition in snow. Here again the spuds have little effect, because what really happens is the shear of snow on snow. This condition remains practically unaffected, no matter how many or how deep the grousers, or what sort of shape they have.

In Fig. 3C are shown experiments made with wheels equipped with 12 grousers. As may be seen, the grousers have packed with soil to the point where instead of a spudded wheel one has an ordinary wheel with a tread of soil. The condition is not changed if the number of grousers is reduced to nine, as shown in Fig. 3D; nor does the use of shorter grousers make any difference. This is illustrated in Fig. 3E, where wooden blocks have been used to shorten the grouser height from 2 to 1 in. Furthermore, in no instance was the drawbar pull significantly affected by these variations.

It will be apparent that this relative ineffectiveness of treads will also apply to rubber tires. Fig. 3F shows that even the "cross country" type of tire is no exception to the general rule. Here again grousers pack with soil; so that a rubber tire practically turns into a wheel of soil, subject to the same limitations as any steel track.

An example of progress made is the evaluation of so-called "grouser action." Theoretically speaking, grouser dimensions do not affect the tractive effort. In actual practice, however, an increase in grouser height does improve the tractive effort to a limited degree. The actual value of this improvement varies with the type of soil negotiated. At first glance this appears rather confusing, and a satisfactory solution somewhat difficult. The situation improves, however, if the general theoretical findings are applied.

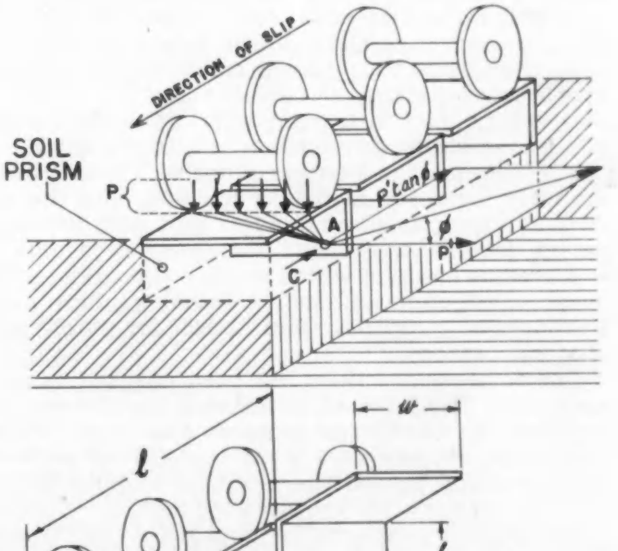
For instance, take a track acting upon a mixture of cohesive and frictional type soils. As is shown in the upper sketch in Fig. 4, the pressure "p" which is distributed over the track shoe due to vehicle weight, radiates towards the sides of the soil prism which slides with the track. Thus, at any point "A" on the side of the prism an additional pressure p′ must be considered. This pressure, when multiplied by the coefficient of friction tan ϕ, gives an additional resistance against slippage, or tractive effort, equal to p′ tan ϕ.

By summing up all the elementary forces—p′ tan ϕ—along both lateral surfaces of the soil prisms and all the elementary forces "c" resulting from cohesion, the total additional tractive effort 4P is obtained. Respective formulas for these grouser effects are shown at the bottom of Fig. 4.

Unfortunately, like other soil mechanics equations, this expression is cumbersome and somewhat complex. The only point of immediate interest is to note that the formula consists of two elements—one due to friction and the other to cohesion.

The established formulas can be applied to all types of soils, and they should be considered general in character. This discloses important information for a designer. For instance, the width of track "w" and the grouser height "h" do not enter the equation individually, but in the form of the ratio $\frac{h}{w}$.

This means that the effectiveness of the "grouser



$$4P = \underbrace{.64\frac{h}{w}\cot^{-1}\left(\frac{h}{w}\right)\tan\phi\left[.64\frac{h}{w}\cot^{-1}\left(\frac{h}{w}\right)\tan\phi + 1\right]}_{\text{FRICTION FACTOR}} + \underbrace{4lch}_{\text{COHESION FACTOR}}$$

Fig. 4—Mathematical expression for grouser effect is shown above. It is based on an analysis indicated in the sketches

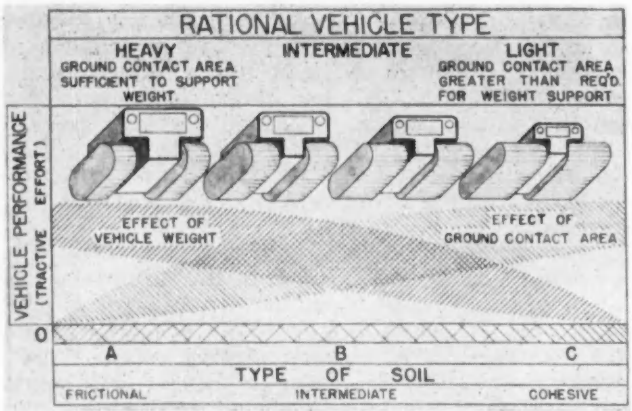


Fig. 5—This chart summarizes fundamental vehicle-soil relationships

action" in frictional soils is not dependent upon grouser height alone but upon the ratio of grouser height to track width. For example, two tracks, one 10 in. wide and another 20 in. wide are used under the same conditions. The grousers of the 10-in. wide track are 2 in. high.

To secure the same grouser effect with the 20-in. track, its grousers should be at least 4 in. high; otherwise the 20-in. track will exert less pull in sand than the 10-in. track. In very sticky clay it might be all right with the 2-in. grousers.

Among other interesting conclusions reached during the above work, the following is of some interest: Higher grousers with narrow tracks are more effective in frictional than in cohesive soils; but any substantial increase in tractive effort of modern vehicles by increasing grouser height is impracticable.

For instance, the grousers of one well known vehicle were increased in height by 300% and the increase in tractive effort was less than 10% in moist, sandy loam. A radical improvement could be achieved by grousers with a depth equal to the track width. Unfortunately, such a design would in most instances be completely impractical for purely mechanical reasons.

The formula discussed has been checked experimentally. The track of an existing tractor was altered by the addition of grousers 3 in. high. Tractive efforts before and after the alteration were measured and proved the practical validity of the calculated effects of "grouser action."

The general prospects for improving vehicle mobility within the scope of current design trends is discouraging. The need for further study to eventually destroy the present inevitability of ever diminishing returns is indicated.

Such a statement seems almost certain to raise many questions, since general conclusions of this nature are probably of greater import than any consideration of the details. The answer to such questions would not be simple, for the research under discussion is only in its infancy and any generalization of the results so far obtained might prove premature. Nevertheless, some general conclusions would seem quite justified, even at this stage.

Before attempting to reach any such conclusions, however, let us examine what appears to be the fundamental laws of the soil-to-vehicle relationship, as illustrated in the composite chart shown in Fig. 5.

Soil types are plotted on the horizontal axis. They start with a purely frictional soil, like sand, at the zero point and end with purely cohesive soils, like clay. Between the two extremes, all intermediate types of soils are represented.

On the vertical axis, vehicle performance is indicated. It is assumed that vehicle performance may be defined by the combination of tractive effort and flotation which makes a vehicle "go." Since it is also assumed that the vehicles possess the required flotation, only the tractive effort need be considered.

First, take the effect of weight upon the tractive effort: According to the findings, this effect reduces sharply when we pass from frictional to cohesive soils. This is shown by the shaded area hatched in dotted lines.

Next take the effect of ground contact area on tractive effort. According to the findings, this effect increases sharply when we pass from frictional to cohesive soils. This is shown by the shaded area hatched in full lines.

Frictional soils belonging to group "A" require heavy tractors of small dimensions for best performance, because they need accomodate tracks or wheels whose contact area satisfies only the "flotation" requirement. Tractive effort is obtained through weight and does not depend on the magnitude of the contact area.

Cohesive soils belonging to "C" group can be negotiated best by lighter tractors. The latter should be large enough to accommodate tracks wider than required by mere "flotation," since traction now depends upon the contact area.

Intermediate soils require a compromise design in order to attain the optimum performance. Research has therefore been aimed at doing this in the most scientific manner possible. Such a compromise is, however, very difficult. Vehicles cannot be designed for crossing cohesive or frictional soils alone. Thus, a universal vehicle for traversing all types of soils should be both heavy and extra large to accommodate tracks wider than required for "flotation" alone.

It is generally agreed, however, that in most cases the maximum in vehicle weight and dimensions has already been reached. Since no substantial improvement in tractive effort can be expected from design changes in track grousers or tire treads, there seems to be little hope of satisfying present day requirements within existing design concepts.

It would thus appear that the ideas which had their origin some 50 years ago have just about reached their ultimate development. Some further progress may be made due to the improvement of materials embodied in these ideas; but this does not offer any hope of a real solution to the problem of cross-country transport. The present outlook for improvement in vehicle mobility within the scope of pervailing trends is therefore rather discouraging.

The new knowledge acquired in this field clearly suggests that new concepts in design are required if modern requirements are to be adequately met. The progress achieved by recent research offers a strong hope that the origination of new trends, which would bring some radical changes, is quite feasible. The final goal, is, however, still quite far away.

Shop Practices Traded at

PRODUCTION CLINICS

INFORMATION-SEEKING engineers, from all kinds of automotive plants, found answers to their own problems and helped others in theirs, at the eight Production Clinic panels on March 15, during the SAE National Passenger Car, Body, and Production Meeting at Detroit.

This, the fourth annual Production-Activity sponsored forum of its kind, yielded a wealth of information on day-to-day manufacturing operations. Production men and design engineers "let down their hair" in the kind of shop talk that bars no holds, pulls no punches. Users and suppliers learned what each wants from the other—and the obstacles in the way of these requirements.

SAE Journal reports highlighting the information from these sessions were made possible by a group of reporters from Detroit Section's Junior Activity. Organized for Clinic Chairman Joseph Geschelin by Philip M. Rothwell, assistant chairman of the Section's Junior Activity, the group consisted of the following: Ruth DeWald, Chrysler Corp.; A. W. Hollar, Eaton Mfg. Co.; W. E. Jackson, DeSoto Division, Chrysler Corp.; Cecil N. King, Chrysler Institute; Don R. Kinker, Chrysler Corp.; Don O'Malley, Chrysler Corp.; Donald H. Nelson, Chrysler Corp.; and Lloyd W. Schuhmann. B. E. Ricks, assistant chief engineer, Thompson Products, Inc., Detroit, stepped in as a pinch-hit reporter on one of the sessions.

Notes and reports by these cooperating Detroit Section members formed the basis for the reports that follow.

Surface Finish

Left to right: C. R. Lewis, Chrysler Corp.; F. R. McFarland, Packard Motor Car Co.; H. J. Griffing, Norton Co.; Panel Leader A. F. Underwood, Research Laboratories Division, GMC; Charles Augey, Ford Motor Co.; and E. J. Abbott, Physicists Research Co.

Based on report by Don R. Kinker

Specify surface finish to suit the part's surface needs, designers were told at this all-day session, but leave method of getting the finish to the production man.

Cylinder bore finish is a case in point. Ring and bore surfaces should be left rough for best alignment and fit after initial break-in. Too smooth a surface makes for low initial wear rate, high oil consumption, and blowby. Too rough a surface leads to high initial wear rate.

Range of from 5 to 30 micro-in. was suggested as perhaps the best compromise.

Discussion revealed that waviness of the bore finish causes blowby and high oil consumption. With a rough surface, this waviness or poor geometry is worn away. But a smooth surface doesn't necessarily have the geometric perfection that insures good sealing.

Engine men said normal operation smooths a surface. It happens to reasonably smooth finishes that wear down to from 10 to 20 micro-in. and to those that wear as much as 0.010 in. The nominal surface will be smooth, despite scratches in the direction of rotation.

A very rough surface initially may never wear in smooth. Instead, it will scuff and the part eventually fail.

In many plants "smooth" finishes are still called for. But no one knows just what it means. Many aeronautical equipment makers eliminate such misunderstandings by detailing finish specifications on some surfaces of all parts. A process sheet with the part drawing gives both linear dimensions and a complete surface specification list.

These three general surface finish classifications sometimes are used: (1) rough—machine cut, (2) smooth—good machine finish, (3) super smooth or fine—ground finish. In most cases, the finer the surface finish, the more expensive the process. Yet this can cut overall cost of build-

ing, operating, and servicing the entire mechanism, several engineers pointed out.

Smoothness required may stem from experience with a particular material and type of operation. But it's best to let the parts themselves dictate the surface finish required. Designers were warned against holding hard and fast to rules.

Good coordination between engineering and production also was urged. The design engineer should specify the finish only; responsibility for determining the method to get this finish should rest with the process engineer. Incidentally, noted one man, the new SAE Surface Finish Standard fosters this breakdown of responsibility.

Interplant coordination also helps improve manufacture by bringing greater machine rigidity and better tools. Result: less need for extra finishing operations.

Several ways to measure surface finish were described. Visual inspection for obvious flaws is one. Blocks with definite roughness finishes are available for visual comparison; but they are limited to comparable types of finishes on similar materials. The profilometer is used for on-the-spot checks. It can help eliminate the need for excessive re-grinding due to worn tools and wheels.

The profilometer cannot effectively measure the "plateau" finish used for high-speed operation. Rough grinding followed by lapping produces this finish.

General Motors-Chrysler geometrically-ruled blocks are under way as smoothness standards for instrument calibration. Progress toward uniformity of surface finish drawing symbols and terminology, also was reported.

High hopes were held for surface finish control of other than machined parts . . . die castings, stamping, furniture, and painted and plated surfaces.

Steel Heat Treating

Left to right: L. E. Webb, Clark Equipment Co.; C. M. Campbell, Chevrolet-Transmission Division, GMC; Panel Leader E. H. Stilwill, Dodge Division, Chrysler Corp.; W. E. Peterson, Gorham Tool Co.; H. B. Osborn, Jr., The Ohio Crankshaft Co.; and E. O. Dixon, Ladish Co.

Based on report by William E. Jackson

Staying within limitations of heat-treat processes brings closer control, according to panel disclosures.

For example, control of distortion is a sore spot in marquenching. This limits the process to certain types of steel (for carburized parts, low-hardenability steels) and transformations. Control factor in induction hardening was noted as shape of the part. Heating rate controls stress distribution in induction-hardened parts. Incidentally, said one engineer, this process does not depend on quench materials for its effectiveness.

The industry is switching from liquid cyaniding to carbonitriding, according to reports at the panel, but selective cyaniding is still being retained. Carbo-nitriding makes better use of oil quenching. Its lower temperatures also help better surface hardness properties. The NH_3 effect decreases as the temperature rises.

From specifics the discussion moved to generalities of heat-treatment. Engineers agreed that distortion depends on depth of hardness. Knowledge of initial stresses from machining and rolling will help control distortion. Case depths are limited by hardenability and cost.

Hot oil quenching requires careful control, several warned, because CO_2 contributes to distortion. Oil temperature depends on the specific job and the distortion allowed. For carburizing steels, an oil temperature of about 170 F proved feasible in one plant.

Forging problems occupied a part of the impromptu agenda. One forging effect is increased ductility due to high pressures. Gains from grain flow or directional properties are found in the ductility and endurance limit, rather than in the elastic limit, one metallurgist emphasized. Directional properties wield no influence on strength and endurance limit.

Salt-bath quench after forging is inadvisable. The quench would take too long and might lead to cracks in heat-treatment. Blasted forgings seem to take heat-treatment better because of removal of scale, which has insulating properties.

Affecting tool steel selections are the equipment, machines, production facilities, and grinding operations. Grain size looms important with regard to uniformity and cost counts too. Much of the high-speed steels used today are in the molybdenum series. But it's tougher and more costly to heat-treat them. Nitriding was recommended for all type of cutting tools contending with abrasion.

Body Steel

Left to right: W. Weirs, Sr., Fisher Body Central Engineering, GMC; H. C. Smith, Great Lakes Steel Corp.; Panel Leader N. E. Rothenthaler, Ford Motor Co.; W. A. Graf, The Budd Co.; and A. P. Lucas, Bethlehem Steel Co.

Based on report by William E. Jackson

The body steel enigma shrunk considerably under a flow of ideas aimed at bypassing the material's shortcomings productionwise.

Panel specialists distinguished between commercial quality and drawing quality steels. The vendor assumes the responsibility for the quality of drawing quality steel. Commercial quality steel is not held to as close tolerances. But this does not necessarily make drawing quality steel better.

No tests can definitely show the difference between these two steels. Main difference is in uniformity. Steel men said they hold to commercial tolerances by designing dies to the low side of the tolerance, regardless of quality type.

The body designer has little choice in the steel used, discussion indicated. Selection is controlled by market availability. Suppliers are not held responsible for meeting the body designer's demands.

One tip given on body steel fabrications is to make large runs on one supplier's materials rather than short runs on steels from several vendors. Try to use up older material first, said one engineer. Then go to large runs, since this insures greater product uniformity.

Stretcher strains in sheet steel were spotted as a headache to the fabricator. One engineer said he found that

ardening the surface improves resistance to stretcher rains. Using the steel as soon as possible after rolling lso minimizes stretcher strain difficulties.

Next came queries on the difference between surfaces of old-rolled steel in coils as against flat sheets. Only advantage cited for flat sheets is easier inspection for defects. But the trend is toward greater use of coiled steel since it aves a shearing operation and costs a lot less.

How long steel retains its surface characteristics after olling depends on the amount of tempering. Several engineers noted that roller leveling followed immediately by stamping helps kill the strain hazard.

Discussion also pointed up a difference of opinion on drawing the prime side of the sheet on the top side of the stamping. Steel suppliers consider the prime side free of defects. But some engineers said it isn't necessarily the better side. They favor inspecting both sides and selecting the one that looks more usable.

Evaluation of laboratory tests showed elongation, cup, and Rockwell tests to give good indication of ductility of cold-rolled sheets. Scribed samples are being used to determine best blank size and to eliminate the transfer to unusable material. Here uniform elongation is most significant.

The bulge test emerged as most conclusive because it is made over a greater area, and is not influenced by minor surface defects and inclusions. Despite the inconclusiveness of grain tests, some laboratories still make them.

Preventive Maintenance of Plant Equipment

Left to right: J. E. Rehm, International Harvester Co.; Otto Klausmeyer, Studebaker Corp.; Panel Leader H. E. Hardenbrook, Buick Motor Division, GMC; W. C. Hartley, Nash-Kelvinator Corp.; O. A. Williams, Ford Motor Co.; and H. A. Zannoth, Cadillac Motor Car Division, GMC

Based on reports by Ruth E. DeWald and A. W. Hollar

Four things are needed to prevent equipment breakdowns; discussion showed: (1) equipment selection, (2) preventive maintenance, (3) personnel, and (4) specific maintenance practices.

Most agreed with one engineer who said equipment maintenance starts with the men who design, specify, and buy. It's tough to keep the equipment running—no matter how sound the maintenance—if the equipment isn't right for the job. The machine vendor should be made to understand the specifications and held to them.

One company found proper equipment selection paid dividends throughout the plant. For example, sealed motors are used because they hold up much longer, even though they cost more initially.

Preventive maintenance programs consist of two functions—record keeping to anticipate troubles, and routine inspections and maintenance.

All agreed maintenance must be scheduled to prevent breakdown. "Prevent the fire rather than be faced with putting it out," most agreed. But setting up such a schedule is a less than simple job, noted another plant engineer.

He said it takes about two years to get a good picture of maintenance problems on a large machine. Only from accumulated records can the inspection schedule be established.

There are four steps in starting such a program: (1) catalog and group all equipment, (2) list items to be inspected, (3) determine what should be looked for on each item, and (4) specify the time schedule. It has been found that electrical parts of conveyors can be inspected semimonthly and mechanical parts, weekly. For lathes and drill presses, monthly inspection works best.

Maintenance records help to foresee trouble. Anticipating breakdowns in advance makes it possible to reschedule jobs and to keep production people busy on other work. One company reduced breakdown time 83% from prewar experience by forecasting sore spots in advance.

Such data, called breakdown statistics by one engineer, have uncovered weak spots in equipment of some plants, which call for improved design or materials. They also indicate minor and major machine overhauls, which can be made at a reasonable time before a statistical machine breakdown.

Records of machine horsepower consumption also can warn of trouble, since wear preceding breakdown generally changes power consumption. Knowing a breakdown is on its way, the maintenance department can repair the machine during slack production, or when it is down for some other reason.

Machine breakdown records also will point out the worst offenders. This gives the production department the facts for justifying replacements instead of continuing with endless repairs of old equipment. This makes possible orderly replacement. Notorious offenders can be made less troublesome by slowing the production rate, eliminating breakdowns (due to overload) and boosting total or running production.

Another engineer said he keeps records to help determine maintenance standards. His records note initial cost of the machine, installation charges, and repairs against it. The accounting department has a continuous record of expense on the machine.

Considerable maintenance labor savings were claimed for preventive maintenance. One plant reduced its total maintenance staff 74%. A second cut general repairs 5%, and halved the number of inspectors and lubricators.

Discussers gave particular emphasis to maintenance personnel . . . how to get them and train them. All agreed the day of the "grease monkey" is over. Every machine today is complicated, specialized, and costly. It takes intelligence to keep it going.

Although it's easy to find young people for tool and die making and other plant work, few are interested in the less glamorous maintenance trades—such as pipe fitting and millwright work. Millwright personnel in one company average 50 years of age. "What will become of these functions, will we be forced to use outside contractors for changing over our production machines and equipment?" asked an engineer from a car factory.

One plant has set up a successful training program for maintenance men. They pick trainees from among their present production employees, steering clear of young high school graduates and older men. Incentive is 5¢ per hr more than production line rates. Journeymen—graduated trainees—are paid considerably more. But before achieving journeyman status, the trainee must spend a minimum time in each department, a longer period in the department he finally selects, and he must pass certain tests.

Exchanging experiences proved particularly helpful to engineers with specific problems. One seeking help on operation of multiple drive conveyors, learned that some plants are using d-c motors. They change their conveyor speed at the beginning of each shift. But with d-c motors, it is necessary to have a dependable person with a synchronized watch at each drive to change drive speeds simultaneously, so that the conveyor won't break.

The magnetic or dynamatic coupling bypasses speed-changing troubles, it was observed. One person at one

location can control the coupling. But this arrangement calls for more drive-motor power because of the energy loss in the coupling itself. One plant finds the installation well worth the added cost, since it eliminated speed-changing snags—like the case when one man missed his timing.

Another engineer told how he overcame failures of limits switches on machine tools and conveyors. One particular switch was submerged in cutting fluid. The moisture made it stick about once a week, requiring a 9-hr shutdown. Neither paint and rubber suppliers nor switch manufacturers could find a way to make the switch absolutely moisture-proof. The switches were moved to dry locations and operated with levers, but this brought new problems connected with lever operation.

The problem was solved by pressurizing the conduit (and thus the switch) with about 10 psi of compressed air. The air escapes through the openings and prevents cutting fluid from entering the switch. There hasn't been a breakdown since this modification was made nine months ago.

Another tip, on silicone varnish in rebuilding electric motors, came from a maintenance engineer. He suggested using the silicone material throughout the entire motor, rather than just on the coils. This includes silicone glass for spacers, such as those between commutator segments. This method makes motors last longer, especially those for hand buffing equipment. The work piece will become too hot for the operator to hold long before the motor fails from over-loading and over-heating.

Best bet for lubricating ball bearings is to use just enough grease to submerge the bottom ball, regardless of the bearing's size. In one shop, maintenance men used to grease ball-bearing electric motors as often as they did those with sleeve bearings. But now, the unwritten law is to lubricate a ball bearing only once.

Materials Handling

Left to right. J. G. Anderson, Cadillac Motor Car Division, GMC; C. H. Huntoon, Lewis-Shepard Products, Inc.; D. W. Kelsey, Union Steel Products Co.; Panel Leader O. E. Johnson, Kaiser-Frazer Corp.; E. W. McCaul, J. B. Webb Co.; O. A. Parmenter, Parmenter Steel and Conveyor Co.; and E. B. Thurston, Houghton Elevator Co.

Based on report by Cecil N. King

Materials handling is moving forward at a quickening pace, thanks to progress in planning methods, specialized equipment, and labor and equipment standards.

One big headache, all agreed, is determining the number of containers for handling a variety of parts. Most engineers at the session saw no easy way out. You must analyze the pieces, following the flow of each part step by step through the cycle. One company checks each department on how many pans it does have, how many it should have, and why the difference, if any.

The plant layout, another helpful planning tool, should show the materials handling equipment needed for each machine.

One system for finding requirements uses IBM setup. A card is set up for each part by part number. Operations sheet information on the container for the part is transferred to the card. With these data, the IBM machine can tell how many different kinds of parts require a specific type of container, and how many containers are needed.

But even such a system calls for details as to distances travelled and tonnage handled. Such actual data set up a base for judging the weight and number of pieces each pan can hold. It's a must with new equipment because it establishes a pattern for future parts. It also backs up requests to management.

Materials handling men were warned not to take the easy way. It leaves them without reasons to justify additional containers when needed.

Labor standards, too, were deemed essential, but lacking in most plants. The man who transfers the part from the vendor's container to the tote pan contributes as much as the man who picks up the part from the tote pan and puts it into the machine tool or automobile.

One car manufacturer establishes labor standards by noting material handling of the part on its operation sheet. This permits evaluation of nonproductive as well as productive labor. It also tells the foreman what containers parts are to come in to him, and the container in which they should leave. Container or rack for each part is specified by the tool engineer.

The flow process chart is basic for determining nonproductive standards. One panel member urged the work simplification approach, using the flow process chart, to help work out many materials handling problems.

Incentive pay for materials handlers met with disapproval. It doesn't work with truck drivers, bringing on accidents and "cowboy" driving. Some felt it isn't fair to set such standards on a ton-mile basis. One company has installed recorders on trucks to tell where the truck has been. It's claimed to make for greater truck usage. Others who tried it find recorders bring grievances from drivers.

Another controversy ensued over centralized versus decentralized dispatching. One group argued against centralized dispatching because of loose truck-driver supervision. A driver crew responsible only to a central dispatcher is less efficient than one reporting to a productive department. With centralized dispatching, foremen argue over use of trucks. One plant, which has tried both methods, found the central dispatcher had a backlog of calls and was always behind.

In another factory, the materials foreman supervises several truck drivers, each of which is assigned to a specific area. He also determines truck usage.

An auto plant finds this method produces divided responsibility. So, it carries the drivers on the payroll of production divisions and they take orders from the production foreman. Each truck is assigned to the production department, even as to maintenance—just like a machine tool.

Pros and cons on the problem simmered down to the fact that both centralized and decentralized dispatch can work; it depends on the type of plant and its operations.

Because central dispatch can't handle equipment all over a large plant, radio-telephone sets have been installed on plant trucks. A parts maker, a Milwaukee boat yard, and a printing company were reported finding radio communication effective. These sets operate on a very short-wave and high-frequency transmission to prevent interference from steel structures in the plant. Radio-telephone installation must be approved by the Federal Communications Commission.

Standardized equipment is much needed, according to demands for it. A uniform pallet is one such item being studied by standardizing bodies.

Some manufacturers are trying to educate truckers and transfer stations to use expendable pallets, showing them what facilities are needed and how to handle these pallets. In fact, one auto maker is even transporting sample loads. Several others are pushing more and more pallets at truckers to force them to get proper equipment.

Both the American Standards Association and the Na-

tional Bureau of Standards were reported to be standardizing freight elevator cars so that they'll take loaded fork trucks.

Hand-operated electric-type trucks, recommended for hauling incoming materials to receiving stories, should be adapted to use of skid boxes and pallets. Estimates of savings realized with them varied considerably. One engineer said the truck should pay for itself within one year. Another claimed one man usually can do the work of two, that his labor costs were reduced 55%, and his trucks paid for themselves within six months.

Big job in handling equipment maintenance is keeping containers clean. This can be done with the pallet inverter, a pallet arrangement that turns upside down to dump dirt. Another aid to cleaning is the knock-down skid box. On this, all the sides come off so that the pallet can be swept clean.

Still a third device is the pallitator, a welded wire box. Dirt as well as liquids, such as rust inhibitors, fall through the wire mesh. In one installation these wire containers pass over a roller conveyor to a washing point, where air and steam are shot through to clean the parts in the containers.

Gear Design and Production

Left to right: Bain Griffith, Chevrolet-Gear and Axle Division, GMC; F. E. McMullen, Gleason Works; Panel Leader R. P. Lewis, Spicer Mfg. Division, Dana Corp.; G. H. Sanborn, The Fellows Gear Shaper Co.; B. F. Bregi, National Broach and Machine Co.; M. D. Elliott, Dodge Division, Chrysler Corp.

Based on report by Donald H. Nelson

Production men consolidated gains with current gear manufacturing methods, while still looking for new and better ways.

Uses and limitations of current gear-making methods they generally agreed are:

1. Gleason method—for cutting spiral bevel and hypoid gears up to 20 in. in diameter.
2. Fellows method—to shape, shave, and burnish spur and helical gears up to 12 ft. in diameter.
3. Hobbing—for spur and helical gears.
4. Broaching—to shave spur and helical gears up to 220 in. in diameter and for involute splines and internal gears.

Manufacturing men swapped information on other gear fabricating techniques. For example, they described burnishing as a process in which the work-piece gear is rolled against a hardened gear. Purpose is to iron out roughness and nicks. It is usually done after hardening, although gears left soft can be burnished too. Burnishing before heat-treating produces excessive distortion because stresses set up are relieved in the heat-treat oven.

Burnishing improves tooth strength somewhat by prestressing the tooth face, but only if the gears are not too hard after heat-treatment to take a deep-enough and uniform burnish.

The burnishing gear itself should be a special one rather than a mating gear. It should have a greater tooth depth to burnish to the root of the tooth.

While burnishing makes little change in the tooth involute form, lapping does because of varying rubbing speeds over the tooth. Some machines use three laps, each operating at a different center distance to equalize stock removal.

Production men said it's good practice to select the lapping compound and application method for each individual gear set. Enough compound must be applied without inducing over-lapping. Pressures of 30 to 35 psi together with a lapping time of 1 to 1.5 min. were recommended.

Formate gears (made with a form tool instead of being generated) are more accurate and cheaper to make, some said. However, they are not any quieter than generated gears since both types are lapped in pairs.

Among the design tips given on cutting gear noise were the following:

1. With high-speed gears, the lower the pressure angle, the lower the noise level. Reason: lower pressure angles make for greater fanufacturing accuracy.
2. Minimum number of teeth in contact on a spur gear set is about 1.4, although 1.25 might be acceptable.
3. Helical overlap insures smoothness and quietness.
4. Making speedometer gears of nonmetallic materials—such as plastics—reduces noise.

Designers also had varied opinions as to the gear side on which the lubricant should be carried. But all agreed the lubricant's real job is cooling; little is needed for lubrication. Lube usually is fed to the outgoing side of heavy-duty gears to get the greatest cooling effect. (If fed to the entering side, some is squeezed out.) Automobile transmission gears usually pick up grease on the entering side.

Standardized gears and gear nomenclature were urged. It was reported that the SAE Drafting Standards will include terminology. But gears themselves no longer are standard. All are modified to satisfy service conditions and cost requirements.

Production and Manufacturing Control

Left to right: J. Gorrien, Briggs Mfg. Co.; J. E. Adams, White Motor Co.; F. E. Boze, Delco-Remy Division, GMC; Panel Leader G. S. Wilcox, Plymouth Division, Chrysler Corp.; E. F. Gibian, Thompson Products, Inc.; and P. A. Miller, Leece-Neville Co.

Based on reports by Don O'Malley and B. E. Ricks

Plants large and small are focusing on more accurate, more positive methods of controlling inventory, production, and costs, said manufacturing men at this panel.

Ways of determining optimum inventory vary from plant to plant. Some keep inventory low because they claimed it requires less control and storage. Others said it depends on the product. For example, in engine manufacture a 35 to 45-day supply is considered low, but efficient.

General philosophy is to keep the lowest inventory that will guard against breakdown and insure smooth flow of production. One engineer viewed inventory as an investment which must be held to a minimum. Another considered a slightly larger inventory worthwhile protection. Its cost is small compared with its shutdown-insurance worth.

Both experience and formulated standards help determine inventories at most plants. Past performance, expected demand, and day-by-day requirements for each

part go into the decision-making. In one shop, this approach disclosed need for parts turnover of from 15 times to once per year.

Another manufacturer predicates his inventory largely on actual orders for the next month. But this he tempers with a yearly forecast, revised every three months, and a fix on production requirements for from six weeks to two months ahead.

Production control discussions centered on the IBM system, exploring its good points and shortcomings. Chief advantage seen for IBM is speeded up answer-getting on accumulated data required by management. While it doesn't give all the answers, it can help tell whether and when there's capacity available for a special program.

Some argued management puts too much emphasis on IBM as a planning medium, not enough on its ability as a production aid. It can provide data on changeovers, cost of a set-up, and parts prices.

On the negative side, production men felt IBM lacks flexibility where production irregularities occur. While IBM machines eliminate much human error, they also make mistakes and must be checked.

An efficient way of using IBM in a job shop was suggested. Instead of hand-posting deductions, an accumulative sheet is set up on a weekly basis and deductions are made once each week. This together with IBM reports makes it possible to detect quickly below-par efficiencies. Such sub-standard work should be called to the employee's attention while the job is fresh in his mind.

Passing cost control down the line to foreman level was hailed as a good move. Some plants already are making foremen control costs for which they can be held responsible. As a part of this budget control plan, foremen are familiarized with overhead, machine, material, and labor costs.

Above-normal operators are compensated through piece work or incentive systems. Under incentive systems, some companies pay for scrap. But if this is a problem, advised one engineer, it's high time that a sound quality control system be set up.

Inspection and Quality Control

Left to right: R. H. Colvin, Burd Piston Ring Co.; Keith Van Kirk, Magnaflux Corp.; G. K. Peets, Packard Motor Car Co.; Panel Leader J. N. Berrettoni, J. N. Berrettoni and Associates; W. H. Vann, Pontiac Motor Division, GMC; S. C. Starnaman, Oldsmobile Division, GMC; George Scranton, Ford Motor Co.; and W. S. Oliver, Timken-Detroit Axle Co.

Based on report by Lloyd W. Schuhmann

Cost-saving facts will sell statistical quality control to management; but it takes control over production and personnel to make it work, advised specialists in the field.

Management can be sold, said several, by showing that quality control pays off. First step in fact-gathering is to get data on the plant scrap rate, rework, and costs on various jobs. Next is to spot savings through quality control by reducing scrap, rework, and manpower, and by boosting productivity.

A trial application of quality control will help back up the "savings" argument, said one engineer who had tried it.

With the facts on hand, it was suggested, start your campaign to sell management, but don't go whole hog. First ask for an okay to set up a trial run. Best place to start is in sore spots, where results will show quickly. But like developing a new product design, it might take a year to show results; and inspection costs may not be reduced.

Second proof-positive suggested for convincing management is experience from another plant getting results with the system. All agreed this was the real sales clincher, especially if the specimen plant is in the same field.

Three kinds of people were suggested to run the trial set-ups: (1) inspection personnel who have especially good records, (2) employees selected for part-time help because of desirable aptitudes, and (3) new people whose salaries can be charged against the experiment.

Control limit discussions focused on acceptable scrap rates in machine shops. Under complete control, said a specialist, a 0.27% rejection rate is statistically possible. But in actual practice, the figure is closer to 2%. A shop man saw little chance of slightly out-of-tolerance parts giving trouble in an assembly. Checking the assembly further lessens the chance of trouble in service.

Experienced men argue that a properly set up system should do a job as good as, or better than 100% inspection. One panel participant noted that the Air Force gives parts a 100% screening three times to get 95% perfection.

Tolerances should be honest, not smaller than necessary, most agreed. Process control limits should be realistic. If control limits won't produce parts to tolerance, it's time to review the engineering tolerances. If tolerances are valid, the only remedy is new equipment that can do the job.

Proper relation between the quality control department, inspector, foreman, and operator will make the system work.

Some said the inspector must be able to shut down the job when it is out of control. Others argued that only in extremely bad cases should he have this authority and then only if closely controlled. They would rather have the inspector tell the foreman (by form order) of the condition, and have the foreman shut down operations.

Both foreman and operator must have the necessary information. One way to give it to them is by a control chart at the machine.

Debate about receiving inspection disclosed differences over sampling plans. Some said actual measurements give more valuable information than does "go, no-go" sorting. Others felt the vendor controlling the job (and that's the trend) simplifies sampling . . . fewer parts need to be checked to insure control.

Standardized acceptance tests are being developed by groups such as the American Quality Control Society, it was reported. The Defense Department also has asked automotive manufacturers to standardize on Army-Navy charts in case of future ordnance production programs.

Quality control also influences labor-management relations, according to discussion. For example, it's most effective in plants paying straight hourly rates, for it develops pride of workmanship. The employee on incentive pay thinks quality control slows down his job.

Many engineers said quality control helps better labor-management relations by producing facts for deciding whether the operator is doing a job. Judging by several cases, when most operators in a plant meet quality control limits, others fall into line.

A foundry engineer and a sheet metal shop man wondered how they could use statistical quality control. The control chart on weight of the casting has been found useful in telling about the foundry operation. In one such case, quality control reduced scrap rate to less than 2%.

The same methods used for machining processes can control sheet metal stampings. The steps advised: study history of the job; sample lot of parts—first from whole department to establish quality level, then from lots of individual operators; for day-to-day control use a patrol inspector for periodic checks; use a chart to trace trend of various factors.

NODULAR IRON
Finds Favor with Ford

BASED ON PAPER* BY

Gosta Vennerholm,

H. N. Bogart,

and R. B. Melmoth

Ford Motor Company

(This paper will be printed in full in SAE Quarterly Transactions together with written discussion. Paper contains additional information on castability, effect of section size and heat treatment on physical properties, and economic considerations.)

ADDING magnesium to molten cast iron, then inoculating the mixture with ferrosilicon causes the graphite to separate out on cooling in the form of nodules. Physical properties of nodular cast iron surpass those of flake-graphite cast iron.

Presence of free graphite in ordinary gray and malleable cast iron endows them with such advantages as high resistance to wear and heat checking, excellent damping qualities, and superior machinability. But the sharp graphite flakes interrupt the surrounding structure and set up high local stress concentrations. The flakes thereby cut down strength and ductility.

The problem has been to get the graphite to form small, smooth, round, evenly dispersed particles that would not concentrate stresses.

It has been found that rounded graphite particles —nodules—can be formed through a two-step process:

1. Addition of magnesium, cerium, lithium, or a similar carbide former to promote formation of white iron in an iron normally solidifying gray.

2. Addition of a ferrosilicon to overcome the tendency toward white iron and to encourage graphite precipitation.

The mechanism of the process is not known with certainty. It may be that the presence of cubic-lattice crystals of carbides or sulfides of magnesium or cerium cause the carbon atoms to orient themselves in a cubic lattice which grows into the nodule form—while conventional cast iron's silica particles, having a hexagonal lattice, form hexagonal, flaky graphite.

Economic and chemical considerations favor magnesium as the stabilizing element. Magnesium can be added as a relatively pure metal, as an element in a nonferrous alloy, or as a magnesium-modified ferrosilicon. In Ford experiments, a magnesium-copper-ferrosilicon has been giving good results. An alloy containing 13% magnesium and 10% copper is used.

The magnesium seems to react first with sulfur in the iron to form magnesium sulfide. Ford experimenters have noted that the magnesium becomes effective in changing the form of the graphite when the sulfur content is down to about 0.02%. Then small amounts of magnesium will refine and shorten flakes. It takes at least 0.035% magnesium to produce completely nodular cast iron. Magnesium in excess of 0.1% will produce stable white iron.

Magnesium becomes gaseous at the temperatures of molten iron and reacts violently with the air. The higher the concentration of magnesium in the addition alloy, the lower the proportion recovered in the iron. The magnesium continues to oxidize at a rate of about 0.001% per min in the ladle. If enough magnesium is added to give an 0.08% initial recovery, the mixture can be held in the ladle 30 to 40 min, as in normal pouring practice, and still contain enough magnesium for completely nodular cast iron.

The amount and method of the magnesium addition depends on such factors as sulfur content, section size, required reproducibility of results, efficiency of magnesium recovery, degree of pyrotechnics consistent with safety, slag-forming tendency, chilling effect, and influence of carrier metal on final analysis.

The magnesium can be added to molten metal poured from cupolas, electric furnaces, or blast furnaces. Of course, the high sulfur pickup associated with cupola operations requires larger additions of magnesium.

* Paper "Nodular Cast Iron" was presented at SAE Annual Meeting, Detroit, Jan. 13, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Table 1—Analysis and Properties of As-Cast High-Strength Nodular Iron

Element	%
Carbon	3.40
Silicon	2.50
Manganese	0.70
Phosphorus	0.14
Sulfur	0.015
Magnesium	0.06

Yield Strength, psi	80,000
Tensile Strength, psi	100,000
Elongation, %	1.5
Reduction in Area, %	1.0
Brinell Hardness	255
Modulus of Elasticity	24×10^6

Cupola Heats—The cupola is charged in the conventional manner.

If high-strength nodular iron is the goal and ductility is secondary, conventional cupola iron may be treated to yield a final analysis and properties as shown in Table 1. Fig. 1 shows the resulting microstructure, a lamellar pearlitic matrix with spherulites interspersed.

If ductility and resistance to impact are the prime goal in the as-cast nodular iron, manganese and phosphorus must be controlled more closely. Manganese should be kept as low as economic considerations permit, preferably around 0.15% and not over 0.30%. Phosphorus must not exceed 0.04% for maximum ductility.

Although high carbon and high silicon contents favor ductility by promoting ferrite precipitation, they can be overdone. High carbon tends to produce more and usually larger nodules. Silicon in excess of 3% hardens the ferrite. Both trends interfere with maximum strength and ductility.

When silicon is to be introduced along with the magnesium, it is necessary to cut down on the silicon present in the melt down. This promotes carbon pickup, thereby improving castability without seriously impairing physical properties.

Table 2 shows a typical spout analysis of a heat intended to yield high-ductility nodular iron through treatment with 0.50% magnesium in the form of a magnesium-copper-ferrosilicon alloy.

Slag on the surface of the molten iron decreases the yield and increases the chance that the reaction with magnesium will proceed with explosive force. So the slag must be removed just before the magnesium treatment.

Ford practice is to pour the slag-free iron at a temperature about 2700 F into treating ladles, adding the magnesium-copper-ferrosilicon alloy in lumps to the stream. Size of the lumps used varies with the amount of metal treated. Lumps roughly 1/8 in. in diameter and smaller are used with 20- to 50-lb ladles; lumps roughly 1 x 1/2 in. are used with 10- to 15-ton ladles.

After the magnesium treatment, the molten metal is reladled into a pouring ladle, and enough 75%-ferrosilicon (which contains 75% silicon) is added in lump form to increase the silicon in the final analysis another 0.3%, bringing the silicon in typical high-ductility nodular iron to 2.60%.

As a result of these two treatments, a heavy,

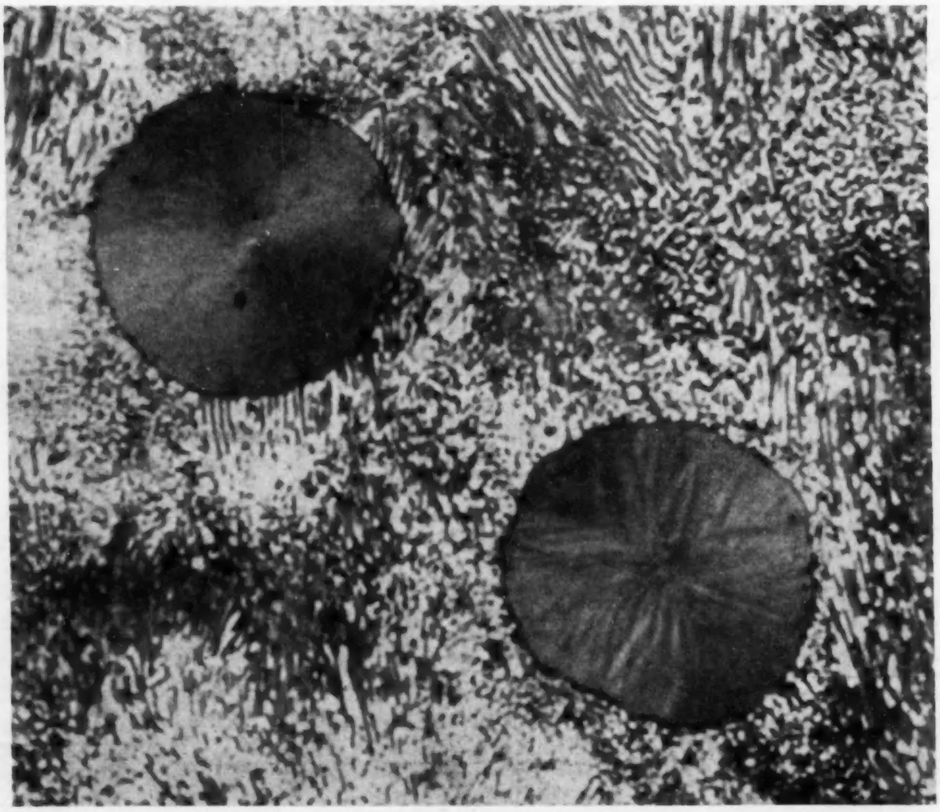


Fig. 1—Microstructure of high-strength, cupola-heat nodular iron

Table 2—Magnesium-Treated Cupola Iron, Typical Analysis

Element	Spout Analysis, %	Magnesium Alloy Addition, %	Inoculant, %	Final Analysis
C	3.50	..	..	3.50
Si	1.10	1.2	0.3	2.60
Mn	0.15	..	..	0.15
P	0.025	..	..	0.025
S	0.10	..	..	0.015
Mg	...	0.5 (13%Mg-Fe-Si)	..	0.05

Table 3—Magnesium-Treated Electric Furnace Iron, Typical Analysis

Element	Analysis, %		Magnesium Alloy Addition, %	Inoculant, %	Final Analysis, %
	Charge	Spout			
C	4.00	3.80	...	...	3.80
Si	1.40	1.25	1.00	0.30	2.55
Mn	1.15	1.00	...	...	1.00
P	0.15	0.15	...	...	0.15
S	0.04	0.04	...	...	0.018
Mg	...	...	0.40 (13%Mg-Fe-Si)	...	0.06

rather dry and powdery slag forms. Either it must be skimmed off before pouring, or tea-pot-spout or bottom-pour ladles used. The surface of the molten metal develops an oxide film which—although it does not seem to influence castability—does decrease the reliability of optical means of temperature measurement.

Fig. 2 shows a sample of the resulting microstructure, a lamellar pearlitic matrix with ferrite surrounding each spherulite.

Electric Furnace Heats—Numerous heats have been made by Ford researchers in furnaces ranging in capacity from 500 lb to 15 tons. Both pig iron and molten blast-furnace iron have been charged.

Typical example is a high-strength nodular-iron heat made in a 15-ton electric furnace. The charge consisted of pig iron of an analysis shown in Table 3. After melt down, the metal was heated to 2700 F and tapped into two 8-ton treating ladles. During tapping, 0.4% magnesium was added in the form of the magnesium-copper-ferrosilicon alloy. The white flame characteristic of oxidizing magnesium accompanied the reaction, but there was no spattering.

The molten metal was reladled into 1500-lb pouring ladles, and 0.3% silicon was added in the form of 75%-ferrosilicon. After careful slagging, the metal was poured into conventional molds, with temperatures ranging from 2550 F for the first ladle to 2400 F for the last.

Fig. 3 shows the difference in graphite formation due to magnesium treatment. The flake-graphite cast iron at the left has a tensile strength of 24,000 psi, a modulus of elasticity of 9.0×10^6 and an impact

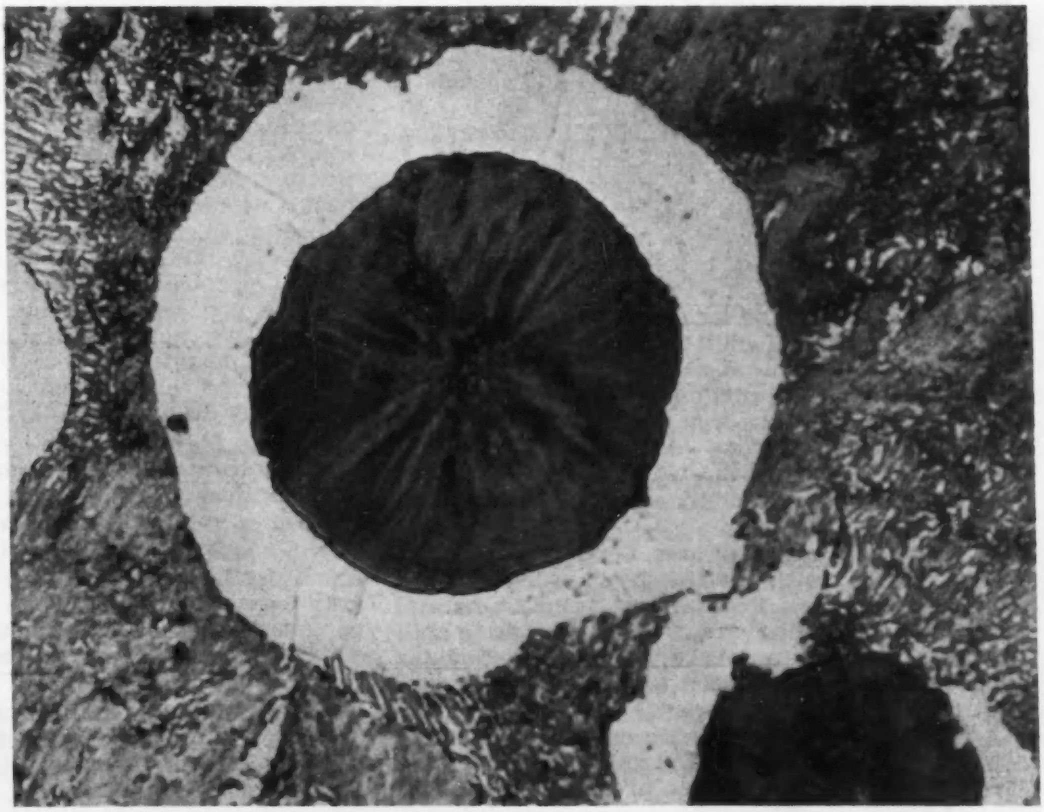


Fig. 2—Microstructure of high-ductility, cupola-heat nodular iron

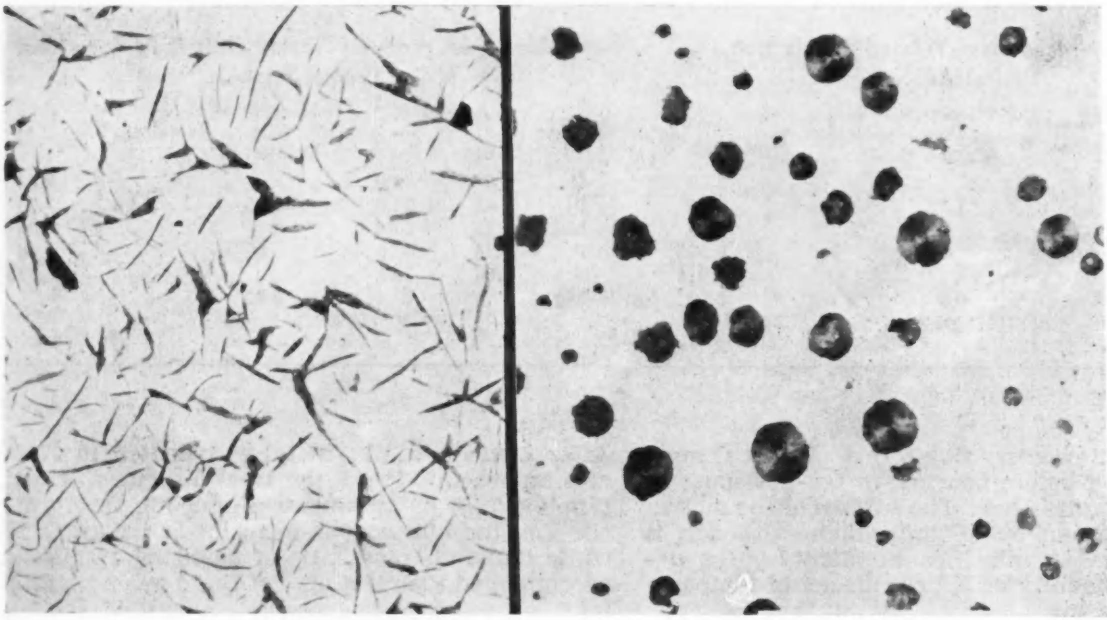


Fig. 3—Microstructure of conventional cast iron at left and magnesium-treated nodular iron at right. (Electric furnace heat)

strength of 13 ft-lb. The nodular-graphite cast iron at the right has a tensile strength of 90,000 psi, a modulus of elasticity of 23.0×10^6, and an impact strength of 40 ft-lb. These physical properties of the nodular iron are difficult to reconcile with the final analysis of the heat given in Table 3, but they are typical of this new material.

Ford researchers use the double ladling technique because they found that addition of magnesium-ferrosilicon alloys alone or simultaneous addition of magnesium alloys and ferro-silicon impaired reproducibility of results and promoted formation of massive carbides. They hope, however, that further research will show how to get good results with a single ladling.

Since the metal is ready to pour immediately after the ferrosilicon inoculation, there is no time to perform a chemical analysis to make sure that nonferrous ingredients are present in proper proportions. As a quick check on composition, Ford casts a chill wedge in a sand mold and fractures it longitudinally. Depth of chill indicates the degree of carbide stabilization. A steely crystalline appearance of the unchilled portion indicates proper treatment. Fracture of an iron with insufficient magnesium gives off a strong odor of hydrogen sulfide when exposed to moist air, whereas a truly nodular iron has the odor commonly associated with acetylene.

Fluidity of properly treated nodular irons compares favorably with that of the base irons at the same temperature. Nodular cast irons or normal gray iron compositions are more susceptible to chill in light sections than are the base metals. Nodular irons respond like cast iron and malleable iron to heat treatments.

A nodular iron will machine more easily than a conventional cast iron of similar physical properties. However, nodular cast irons are usually used in higher hardness ranges. Of course, when a nodular iron replaces a softer cast iron, the nodular iron may be more difficult to machine.

Resistance of nodular iron to lubricated wear is excellent, particularly if there is no free ferrite.

On the basis of its qualities, nodular iron appears to have four potential fields of application:

1. Where nonflaky graphite in a selected matrix has proved successful. (From an engineering standpoint, this would place nodular iron in competition with various malleable irons and graphitic steels. Ford has been studying suitability of nodular iron as a replacement for present graphitic steel for crankshafts. Results are promising.)

2. As a replacement for conventional cast iron where greater tensile strength or resistance to impact is needed.

3. As a replacement for steel castings where better castability or machinability is required.

4. As a replacement for wrought steel in such items as concrete-reinforcing bars. (Nodular iron has been hot-worked in the neighborhood of 1750 F with good results.)

A study of the economics of replacing currently used materials with nodular iron indicates that:

1. *Malleable Iron*—There is no immediate economic advantage in replacing present malleable iron castings with nodular iron. Early application of nodular iron in the malleable field may be limited to section sizes larger than those possible at present.

2. *Gray Iron*—Competition of nodular iron with gray irons will be solely on the basis of improved engineering properties, except in the case of certain alloy irons where an economic advantage is indicated.

3. *Steel*—Use of nodular iron in the steel foundry industry will probably be limited to cases where improved castability and machinability will offset the higher cost of nodular iron.

Uniform Fluid Type Specified For Automatic Transmissions

EXCERPTS FROM PAPER* BY

H. R. Wolf and J. L. McCloud

Research Laboratories Division, GMC — Ford Motor Co.

A SINGLE type of fluid, qualified by Armour Research Foundation, for use in passenger-car automatic transmissions, accrues benefits to car owner, petroleum refiner, and car manufacturer.

For car owner:

It provides an identification that motorists can easily recognize at service stations and enables them to avoid improper or inferior products.

For oil refiner:

It broadens the marketing of fluids through oil company service station outlets, decreases the number of types and viscosity grades and greatly simplifies servicing units in the field.

For car manufacturer:

It offers all car and automatic transmission manufacturers an opportunity to specify fluids of known performance characteristics for use in service.

When the fully-automatic transmission was first introduced as optional equipment on passenger cars, the special fluid required for satisfactory operation in service was not available through the petroleum industry retail marketing channels. Previous service experience with semi-automatic transmissions demonstrated very conclusively that the success of the fully-automatic transmission depended in large part on the use of a suitable fluid, compounded to perform as an integral part of the transmission. Since the success of an automatic transmission depends on the continued use of the correct fluid, and since a fluid having the required properties was not distributed by the petroleum industry, it was therefore necessary for the car manufacturer to assume the responsibility for making available to the car owners fluid having the required performance characteristics. As a temporary expedient the car manufacturer supplied production fluid as a service replacement part through its authorized car dealers.

The tremendous increase in the number of automatic transmissions in service now makes it desirable for the retail gasoline filling stations to be in a position to service these units at the same time other lubrication work is performed. Obviously, the petroleum industry cannot be expected to supply, through their gasoline filling stations and other retail marketing outlets, different types and viscosity grades of fluids for use in each of the different models and types of automatic transmissions. This would result in no end of confusion and in general misapplication of these special fluids.

Standardization of fluids for passenger car automatic transmissions, including torque converters, was required before these products could be merchandized through the regular petroleum industry channels. In addition to standardizing on a single fluid for passenger car use, some mechanism must be provided for qualifying and for identifying fluids which meet the requirements of the equipment manufacturers.

This mechanism, if it is to serve the best interests of the car owners and secure the support of the equipment manufacturers, must not only provide for the distribution of properly formulated and qualified fluids; but, of even more importance, it must insure to the car owner and to the car dealer a means for readily identifying a properly formulated and qualified fluid and enable them to avoid the use of improper and inferior fluids offered by marketers and jobbers who are not fully appreciative of the exacting requirements.

* Paper "Automatic Transmission Fluid, Type A, for Passenger Cars," was presented at SAE National Fuels & Lubricants Meeting, St. Louis, Nov. 3, 1949. (This paper is available in full in photolithographed form from SAE Special Publications Department. Price, 25¢ to members, 50¢ to nonmembers.)

One approach to the problem of qualifying automatic transmission fluids by petroleum refiners and marketers for direct sale to car owners, presented by General Motors Corp., outlines the detailed requirements for a single fluid which will provide satisfactory operation in all past and current model General Motors passenger car automatic transmissions. Included is a procedure by which interested petroleum refiners and marketers can qualify their products for use in General Motors cars. Each company, of course, will market its fluid under its own brand or trade name.

The program proposed by General Motors Corp. was formulated to cover not only the Corporation's requirements for a single fluid for use in both the Hydra-Matic and torque converter type of current production automatic transmissions, but also to enable other equipment manufacturers to take advantage of the standardization and qualification procedures without referring to the fluid as a General Motors product. This is a distinct advantage, not only to the automotive industry, but more importantly, to the petroleum industry, as it permits the use of a single fluid in service, thereby greatly simplifying the problem of recommending fluids and avoiding the confusion which would result in servicing units in the field with the wrong fluid.

To successfully establish a long range program which will permit the fluid-servicing of automatic transmissions, by gasoline filling station and independent garages, it is imperative that the minimum number of fluid types be supplied. Similarly, the necessity for standardization of each fluid type is obvious.

Nomenclature

When the automatic transmission was first introduced to the public some ten years ago the new car owner had a great deal of respect for, and probably some apprehension about, the intricate nature of a fully automatic transmission. Consequently, he did not hesitate to follow exactly the instructions, given in the car owners manual, to obtain all servicing, including fluid, from the car dealer. With the practicality of the automatic transmission now firmly established, many owners and filling station operators do not fully appreciate that the correct fluid is essential for trouble-free operation.

The use of engine oils and inferior substitute fluids can result in serious and costly service failures. Inferior fluids do not generally cause immediate failure and, consequently, give the owner a false sense of security. Gasoline low in antiknock value is detected almost instantly by the car owner, but fluids low in oxidation resistance require several thousand miles of operation before oxidation products accumulate in sufficient quantity to interfere with the operation of the transmission and be detected by the car owner.

To emphasize the necessity for using a fluid designed especially for automatic transmissions, a uniform and well recognized nomenclature is required. The designation "Automatic Transmission Fluid, Type A," prefixed by the marketers own brand or trade name, has been adopted to identify the type of fluid required for current production passenger car automatic transmissions. Wide spread use of the generic name, "Automatic Transmission Fluid, Type A," by both the automotive and petroleum industries will assist materially in constantly calling attention to the necessity for correct fluid-servicing of automatic transmissions in passenger cars.

Type A Fluid

Different designs of automatic transmissions may require fluids of somewhat different functional characteristics. Generally these differences reflect in the degree of oxidation resistance and the range in viscosity required for the most efficient operation.

At the present time three viscosity ranges are required to service the commercial automatic transmissions now in production and in use in the field. An extremely light fluid having a viscosity of approximately 35 sus at 100 F is specified for one design of torque converter which is used largely in the industrial field. A slightly heavier fluid having a viscosity of approximately 65 sus at 100 F is specified for use in a different design of torque converter used primarily in the bus and coach field. A third fluid, having a viscosity of 54 to 56 sus at 210 F, is required for the current production models of passenger car automatic transmissions.

While much has been accomplished in the standardization of a single fluid for use in current models of both the Hydra-Matic and torque converter types of automatic transmissions, no assurance can be given that this particular fluid will remain the best compromise for future designs of passenger car transmissions. A lower or even a higher viscosity fluid may be required in new designs at some future time. Regardless of future requirements, the present fluid will be needed for service, for a number of years, in the present production models.

To establish a nomenclature that will provide for future developments and to avoid confusion which may result from the introduction of additional types of passenger car fluids, the present fluid has been designated as "Type A." If and when additional viscosity ranges are required, they may be designated as "Type B," "Type C," and so forth, or by other appropriate designations.

To date, the recommendations for fluids in industrial units and in the bus and coach field have been handled by the individual equipment manufacturers largely in terms of brand or trade-names based on experience in service. As the use of these units is extended to other fields, and particularly when it becomes desirable to expand the fluid-servicing of these units, the required fluids may be identified as Automatic Transmission Fluids, with an appropriate type designation to indicate the specific use for which each grade is intended.

General Requirements

An automatic transmission fluid must perform a number of different functions; the exact combination of properties required in a specific fluid depends entirely on the design of the unit in which it is used and on the operating conditions.

In automatic transmissions employing a fluid drive or a torque converter, the fluid serves as a power-transmission medium, a heat-transfer medium, and a lubricant for bearing surfaces. Many automatic transmissions also utilize the fluid as a hydraulic control fluid and a gear lubricant.

To satisfactorily perform all of these functions under all service operating conditions in different type and models of passenger car automatic transmissions, fluids compounded by different refiners for direct sale to car owners and car dealers do not necessarily have to be compounded on the same formulation, but they must provide:

a. Complete miscibility with the fluids used by the equipment manufacturers for the initial factory fill and with all other fluids available for use in service,
b. Maximum resistance to oxidation,
c. Operation over a maximum temperature range,
d. Mimimum volatility,
e. Mimimum antifoam characteristics,
f. Maximum protection against corrosion and rusting of component parts,
g. Mimimum effect on seals,
h. Freedom from squawking or chatter in units where a change in ratio is accomplished by shifting under engine power, and
i. Freedom from toxic properties.

Each of the above requirements may not be necessary for satisfactory operation in each individual transmission design; however, the concept of a single fluid for use in all current passenger car automatic transmissions requires somewhat broader fluid characteristics than would be required if individual fluids were designed for each individual unit.

The advantages to the equipment manufacturers and the petroleum marketers gained through the use of a single fluid far outweigh any slight economy in original fluid cost and avoid the confusion that would result from the use of a large variety of service fluids, each designed for an individual transmission unit.

Detailed Requirements

To enable petroleum refiners and marketers to supply, through their retail filling stations, fluids equal in performance characteristics to the service replacement fluids marketed by their parts and accessories departments to their authorized car dealers, General Motors has established the following minimum requirements for "Automatic Transmission Fluid, Type A" for use in Hydra-Matic and Dynaflow transmissions:

a. Miscibility,	Pass
b. Viscosity, Saybolt Universal 210 F,	54 sec, minimum 56 sec, maximum
c. Viscosity Index,	150 F minimum
d. Flash Point,	365 F minimum
e. Fire Point,	395 F minimum
f. Pour Point,	-35 F maximum
g. Copper-Strip Test,	Pass
h. Antifoaming Properties,	Pass
i. Heating Test,	Pass
j. Noncorrosion and Nonrusting Properties,	Pass
k. Effect on Seals,	Pass
l. Odor,	Pass
m. Nontoxic Properties,	Pass
n. Oxidation Test on Fluid as Marketed,	Pass
o. Oxidation Test on Fliud diluted with equal volume of Reference Oil,	Pass
p. Nonchatter or Squawking Properties,	Pass
q. Durability (Cycling Test),	Pass
r. Viscosity Stability,	Pass
s. Frictional Properties, and	Pass
t. Performance in Transmissions under Service Conditions.	Pass

The above minimum requirements, except for a slight change in viscosity and viscosity index, are identical with the present requirements for current production and service fluids used in Hydra-Matic and Dynaflow transmissions.

A number of refiners are now developing fluids to meet these requirements. They should be in commercial production early in 1950.

Automatic Transmission Fluid, Type A will be available to all equipment manufacturers for initial factory fill and for service. In some specific designs all of the properties incorporated in the Type A fluid may not be required; manufacturers of these units may elect to use fluids of their own formulation for the initial factory fill and take advantage of the Type A fluid only for service.

Properties Affect Performance

Most of the requirements are obvious; however, a brief discussion of the individual properties may be of interest, particularly in the development of new fluids.

Miscibility: Regardless of the merits of an individual fluid it must be miscible with all fluids used in production by the several equipment manufacturers; and each new fluid designed for use in service must be miscible not only with the production fluids, but also with all previous and current service fluids.

Viscosity: The viscosity requirement is fixed not only by the design of the hydraulic power transmission section of the unit, but is influenced by the other multiple functions which the fluid must perform. These include general lubrication, gear lubrication, clutch and service lubrication and the operation of hydraulic controls.

The viscosity range at 210 F in the modified Type A Fluid has been increased slightly to permit higher pressures at higher operating temperatures in the hydraulic control systems to insure more satisfactory performance under extreme service operating conditions.

Viscosity Index: A high viscosity index is required to provide the maximum range in operating temperature and to eliminate seasonal fluid changes. The increase to a minimum viscosity index of 150 in the modified Type A Fluid was made to provide improved operation over a wider temperature range and to insure that a single fluid can be used in all current passenger car production automatic transmissions.

Flash and Fire Points: Maximum flash and fire points, consistent with other physical properties, are required to minimize fire hazards in operation and to reduce the tendency toward cavitation caused by vaporization in the hydraulic power transmission section.

Pour Point: A low pour point is required to insure pumpability of the fluid at low temperatures.

Copper Strip Test: The conventional copper-strip corrosion test is included as a preliminary test to detect fluids containing addition agents that may have a detrimental effect on copper alloys.

Anti-Foaming Properties: The fluids are circulated rapidly in operation and air may be entrapped. Excessive foaming may cause over-flow and loss of fluid. Entrapped air also interferes in the operation of the power transmission unit and hydraulic control devices and may cause operational failures in service.

Heating Test: The heating test is a preliminary test to determine the ability of the fluid to withstand prolonged heating at high temperature without decomposition.

Rust Prevention: Moisture may accumulate through condensation under some operating conditions; consequently, protection of the component parts against rusting or corrosion is essential.

Effect on Seals: The synthetic seals used in automatic transmissions were developed to have the maximum resistance to changes in dimensions and in hardness in contact with production fluid at high temperature. The effect of a fluid on the seal material is determined by the source and method of processing of the base stocks used in compounding the fluid and may be modified by the additive agents.

Odor and Nontoxic Properties: The necessity for a fluid free from odor and toxic properties in a passenger car is obvious. The fluid must also be nontoxic to the personnel engaged in servicing units in production and in the field.

Oxidation Resistance: Automatic transmission fluids require a higher degree of oxidation resistance than engine oils. CLR L-4 oxidation tests are therefore required on the fluid as compounded and on the fluid after dilution with an equal volume of a mineral reference oil free from added oxidation inhibitors. This combination of L-4 oxidation tests is intended to insure the proper degree of oxidation resistance and to detect fluids which may precipitate soluble oxidation products when other types of fluids are used for make-up or for replacement in service.

Non-Chatter or Squawking Properties: Chatter and squawking, which is a "stick-slip" phenomena, requires special emphasis on the frictional characteristics of the fluid. These properties are evaluated in the durability or cycling test, the OM2 bearing test, and in the actual road performance tests.

Durability Test: This is a laboratory simulated service cycling test on a full scale, engine driven, production unit in which the operation is conducted under full engine power through the entire speed range. This test was designed to reduce the amount of actual road durability testing that would otherwise be required to evaluate performance in service.

Viscosity Stability: The viscosity stability test also reflects the oxidation resistance of the fluid and is based on the change in viscosity of samples withdrawn at intervals during the durability test.

Frictional Properties: The frictional properties of a fluid determine the nonchatter of squawking characteristics and the smoothness of operation of clutches and servo-mechanisms. The OM2 bearing test is also used to indicate any reaction of additive agents present in the fluid with bearing or frictional surfaces that might form surface films which would have an adverse effect on their frictional characteristics.

Performance Tests: Performance tests, conducted on the road under severe operating conditions in several different types of automatic transmissions, serve as a final check on a fluid to assure satisfactory performance under all field conditions.

Qualification of Type A Fluids

A program for qualifying "Automatic Transmission Fluid, Type A" has been developed with Armour Research Foundation. This program is being sponsored by General Motors Corp. to identify to car owners and car dealers fluids which are equivalent in performance characteristics to the fluids that are distributed as service replacement parts by their parts and accessories departments to authorized car dealers.

The final criterion for an automatic transmission fluid is the same as for any other component part—it must provide satisfactory operation under all conditions encountered in service for extended periods of time. This would require actual performance and durability service tests. Such tests are not only extremely expensive and time consuming, but would greatly limit the number of fluids that could be examined.

Since performance characteristics, based on extended previous service experience, can be expressed quite accurately by physical properties and simulated performance tests, the preliminary laboratory testing procedure conducted by Armour Research Foundation serves as a rapid screening process to permit final appraisal by less complex performance and durability tests. The performance tests will be conducted by General Motors in current production units.

The qualification program provides for a review of the laboratory and performance test data by the General Motors Committee on Automatic Transmission Fluid. This Committee is composed of members of the engineering staffs of the manufacturing divisions and a representative of Armour Research Foundation.

Qualification numbers are issued by Armour Research Foundation to identify the individual products which meet the minimum requirements for "Automatic Transmission Fluid, Type A."

Interim Fluids

Some time will be required by the petroleum industry to develop and qualify the modified Type A fluids. During this interim period, until distribution can be established, and a complete change-over can be made to the modified product, arrangements have been made whereby petroleum refiners and marketers may qualify current production fluids for resale under their own brand or trade-names.

These interim fluids are now being distributed by a number of petroleum marketers and are being offered for direct sale to car owners under the designation "Automatic Transmission Fluid, Type A."

The modified fluid will continue to be designated

as "Automatic Transmission Fluid, Type A"; consequently, the change-over can be accomplished in an orderly manner without any change in container design and brand or trade-name.

Equipment Manufacturers' Recommendations

The individual equipment manufacturers must be responsible for the type of fluid used for initial factory fill and for recommendations to their service organization and to their individual car owners.

General Motors car divisions and the Lincoln-Mercury Division of the Ford Motor Co. are recommending to their car dealers and car owners the original equipment fluids, which are available to all authorized dealers through their respective Division Parts and Accessories Departments, or a properly qualified AUTOMATIC TRANSMISSION FLUID, TYPE A supplied by a reputable marketer and identified by an ARMOUR QUALIFICATION NUMBER, for use in all General Motors passenger car Automatic Transmissions and in the Lincoln Hydra-Matic Transmission.

Other car and equipment manufacturers, who require a service fluid of similar properties, may specify the use of "Automatic Transmission Fluid, Type A" in their units with the assurance that they are recommending a product of known performance characteristics which is accredited by a neutral laboratory, and which can be readily identified by the car dealer and by the individual car owner.

Brake Performance Limited by Heat

Based on paper by

PAUL J. REESE

Wagner Electric Corp.

HEAT dissipation is a growing "bugaboo" in brake drum design that's also making itself felt in lining performance.

Trouble is that brake drums of conventional design can't get rid of heat from braking fast enough. Drum surfaces get as hot as 1400 to 1500 F in severe service; outer side of a heavy section drum may remain relatively cool—300 to 400 F. The surface metal expands more rapidly than the rest. Unequal expansion causes checks in the surface, which may deepen and eventually crack through the drum section.

Tensile strength of brake drum iron drops from 35,000 psi at atmospheric temperature to 2000 psi at 1200 F. (Actual tensile strength loss depends on drum thickness, design, and material.) This limits the drum's ability to flex under shoe pressure. Every point on its circumference is alternately stressed in tension and compression several times in each revolution.

Braking-generated heat also lowers the friction coefficient of the lining. This reduces torque exponentially. Because the shoe heats up more slowly than the drum, its radius becomes less than that of the drum. Less shoe contact area results and further reduces torque.

Continued severe braking will rapidly burn and wear the lining surface to the radius of the enlarged drum. After the drum cools, shoe radius will be larger than normal. Pressure also will be higher and induce abnormally high self-actuation until the lining has worn to the cool drum's radius.

Engineers are trying to increase the drum's heat-dissipating capacity in two ways: (1) by adding cooling ribs to expose more drum area to surrounding air, and (2) by coring ventilating holes in the brake drum dish to circulate more air over the drum surface. Investigations are now under way on hardened alloy iron drums, aluminum drums with cast-iron and sprayed-steel liners, and cast-iron drums with copper cooling fins and aluminum fins.

The paper also describes factors imposed on other brake system components and road surface influence on braking effectiveness. (Paper "Automotive Braking Problems," was presented at SAE Northwest Section, Seattle, March, 11, 1949; SAE Oregon Section, Portland, March 13, 1949; SAE British Columbia Section, Vancouver, March 16, 1949; and SAE Kansas City Section, Dec. 12, 1949. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

BASED ON PAPER* BY

G. Mervin Ault
and G. C. Deutsch

Lewis Flight Propulsion Laboratory, NACA

NACA ... For

(This paper will be printed in full in SAE Quarterly Transactions.)

NACA's search for better gas turbine blading materials has led from high-temperature alloys and ceramics to ceramals—promising new materials which combine the elements and some of the useful qualities of both.

Currently used high-temperature alloys are operating close to their temperature limits. So NACA researchers turned to ceramics because they have higher melting points and, therefore, offer promise for finding utility at temperatures above the softening temperatures of currently used alloys.

Certain ceramics did show favorable strength-weight ratios at high temperatures, but they tended to fracture on exposure to sudden drastic temperature changes, which can't be avoided in turbines. Besides, their brittleness made them hard to handle without breakage.

Theoretical analysis of near brittle materials showed that their resistance to thermal shock varies directly as thermal conductivity and tensile strength, and inversely as linear coefficient of thermal expansion and ductility modulus. This suggested that adding metal to ceramic might improve thermal-shock resistance by increasing thermal conductivity and ductility.

NACA chose to investigate addition of metals to two ceramics: boron carbide, the strongest of a group of ceramics they had investigated, and titanium carbide, the most resistant to shock. To the boron carbide, they added iron. With the titanium carbide, they used separately cobalt, tungsten, and molybdenum.

Boron Carbide Ceramals

Bonding tests indicated the superiority of iron as the metal constituent for use with boron carbide. For these tests, dimples were ground into high-density slugs of hot-pressed boron carbide, then heaped with powdered metal. Loaded slugs were heated in a helium-atmosphere furnace to various temperatures above the melting points of the metallic powders.

Microscopic investigation of the interface between each slug and its powder showed that chromium merely wet the surface of boron carbide and had little adherence, but cobalt and iron adhered well and penetrated the matrix of the ceramic at 300 F above their respective melting points. And nickel showed the same property at 600 F above its melting point.

Iron was the logical choice for study because it is the most readily available of the adhering metals.

* Paper "Review of NACA Research on Materials for Gas-Turbine Blades" was presented at SAE Annual Meeting, Detroit, Jan. 12, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

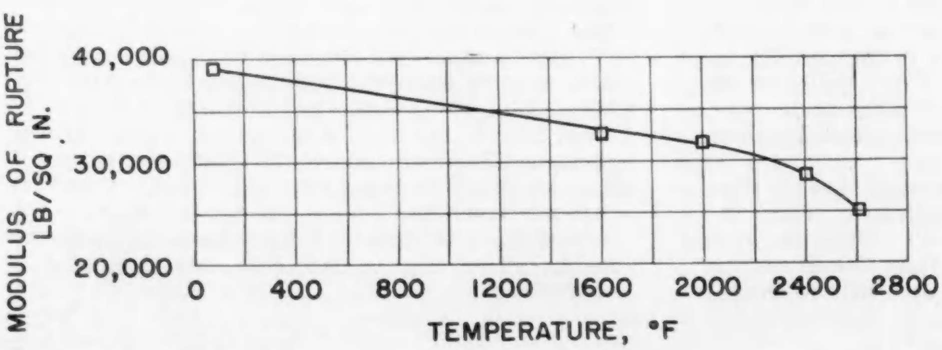


Fig. 1—Transverse rupture strength for titanium carbide plus iron ceramals

Studies Ceramals

TURBINE BLADING

Preliminary examinations of boron carbide—iron combinations lead to investigation of a body 36% iron and 64% boron carbide by weight.

Strength of this boron carbide-iron ceramal was determined in transverse bending. (Reason was that this method is easier to use with ceramics and ceramals than the usual tensile pulling. Strength determined in transverse bending is that of the extreme outer fibers of the bars and is empirically roughly twice the tensile strength.) Small rectangular bars were placed on two supporting knife edges and loaded through an opposing knife edge half way between. Testing was done in an air atmosphere.

Fig. 1 shows variation in strength with evaluation temperature of the ceramal. Strength of the ceramals is consistently lower than that of pure boron carbide, but the rate of decrease in the ceramal's strength with increase in temperature is very low. At 2400 F, the ceramal has lost only 27% of its room-temperature strength, although it contains 36% iron. As the ceramal weighs 3.30 g per ml, its strength-to-weight ratio is high.

While this ceramal proved weaker than its ce-

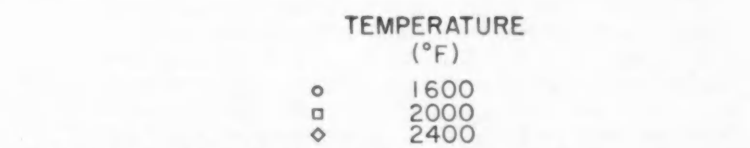


Fig. 2—Trends in transverse rupture strength for titanium carbide ceramals

ramic constituent, the ceramal had better thermal-shock resistance—although it was still relatively low. When small rectangular specimens were heated and air quenched, the ceramal withstood an average of 25 quenches from 1800 F plus 8 quenches from 2000 F. Pure boron carbide averaged only 6 air quenches from 1800 F. (A specimen was considered to have failed when a crack was detected.)

In oxidation resistance, the ceramal was superior to the ceramic at 1600 F but inferior at 2000 F. Oxidation characteristics of the ceramal indicate that this composition will require external protection for operation above 1600 F.

Titanium Carbide Ceramals

Titanium carbide ceramals were investigated more extensively. Cobalt was known to bond well with cemented-carbide tool compositions, so it was chosen as one of the metal constituents to be studied. Tungsten and molybdenum were chosen as examples of more refractory metals.

Ceramals of titanium carbide with 5 to 30% metal constituent were fabricated by Kennametal, Inc. for NACA. Densities ranged from 5.08 g per ml for the 5% cobalt ceramal to 5.88 g per ml for the 30% tungsten ceramal—about two-thirds the densities of currently used high-temperature alloys. (For turbine blades, the lighter the material the better because centrifugal force increases with density.)

Purpose of varying the proportion of the metal to the ceramic in the ceramals was to discover the optimum composition. It was expected that below the optimum the metal content would be insufficient for good bonding and above the optimum excess metal would interrupt the carbide-rich phase and weaken the body. Although the data tend to confirm this supposition, they are not conclusive.

In transverse bending tests, cobalt-bearing ceramals exhibited exceptional strength up to 2000 F but negligible strength at 2400 F, as Fig. 2 shows. The tungsten and molybdenum compositions, on the other hand, have only moderate strength at the lower evaluation temperatures but considerably surpassed the cobalt ceramals at 2400 F.

Of the titanium carbide ceramals, only the 20% cobalt ceramal was tested for resistance to fracture by thermal shock. The sample withstood 25 quenches from each of the four evaluation temperatures, 1800, 2000, 2200, and 2400 F, without fracturing. This latter temperature was the limit of the apparatus, so the test was terminated.

The cobalt-bearing bodies were the most oxidation resistant of the titanium carbide materials, probably because of the thin tight oxide coating formed. The oxide formed on the molybdenum-bearing ceramal offered no protection against further oxidation. All of these ceramals would require external protection against oxidation except where service lives under 10 hr are acceptable, it was found.

Properties of the 20% cobalt—80% titanium carbide ceramal were so favorable that the material was made up into turbine blades and run in a small test turbine. Test runs indicated that to use these strong but brittle materials, design of both disc and blades must differ in many ways from designs used with present alloy blades. For example, because of the high thermal conductivity of the ceramal blades, discs must be designed to run at higher rim temperatures. But these tests—some lasting as long as 110 hr—bolster the hope that ceramals may eventually permit the operation of jet engines at higher temperatures.

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Discussion

Excerpts from discussion by

—J. C. Redmond
Kennametal, Inc.

That the titanium carbide-cobalt materials are deficient in oxidation resistance was recognized by our laboratory, and work was undertaken to improve the resistance. This was accomplished by the substitution of a small percentage of columbium and tantalum carbides for part of the titanium carbide. Decreases in oxidation rate of up to 40 times have been noted. About 8% columbium has been used, but it has more recently been found that a maximum of 4% will produce the same effect.

It therefore appears that the means are available to provide these materials with sufficient oxidation resistance for use as blades with gas inlet temperatures up to 2200 F.

Considerable work has also been done on the use of nickel as the auxiliary metal in place of cobalt. Our preliminary results indicate that both the physical properties and oxidation resistance are improved. This is very fortuitous in view of the less strategic nature of nickel.

RADIOISOTOPES

Serve Metallurgy

BASED ON PAPERS* BY

R. A. James, Chrysler Corp.

William Reid, Ford Motor Co.

and Dr. Keith Symon, Wayne University

* Papers "Radioactive Isotopes for Detection of Submicroscopic Quantities of Material Transfer" by James, "Industrial Application of Radioisotopes" by Reid, and "Radioisotopes" by Symon were presented at SAE Detroit Section on Oct. 17, 1949. (These papers are available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ each to members, 50¢ each to nonmembers.)

METALLURGISTS are using radioisotopes to trace movement of minute quantities of metal and coke constituents and even to indicate the amount of liquid metal in cupolas.

They can secure radioisotopes of an element under study in a specimen either by compounding it from both radioactive and stable isotopes of the element or by irradiating the specimen in an atomic pile. The metallurgical industries report more uses for the first method, so far. The second method has been applied to friction and wear studies, but there are three possible obstacles to its use:

1. Formation of unwanted isotopes of the same or

Glossary of Tracer Terminology

nucleus of atom contains positively charged **protons** and uncharged **neutrons**

electrons bear negative charges and revolve around the nucleus. Number of electrons in atom's shell determines its chemical behavior

atomic number of an element equals the number of protons in its atomic nucleus

mass number of an element equals the number of protons plus neutrons in its atomic nucleus

isotope—type of atom of a particular mass number. (All atoms of a given element have the same number of protons in their nucleus, and therefore the same atomic number, but may have any of several numbers of neutrons. For example, iron may have mass numbers from 54 to 59. Iron 54 is one isotope, iron 55 another, . . .)

radioactivity—disintegration of atomic nucleuses with emission of charged particles (**alpha** and **beta rays**) or very-short-wave electromagnetic radiation (**gamma rays**)

radiograph—picture produced on a photographic plate by a form of radiation other than light

radioisotope—radioactive isotope

ionization trail—region of electrons torn off atoms in the path of alpha and beta rays. (A gas is a better electrical conductor when ionized than when not ionized.)

ionization chamber—device for measuring conductivity of small volume of gas produced by radiation; measures intensity, or *average* ionizing power, of radiation passing through it

geiger counter—device consisting of cylinder surrounding electrode which detects current set up by *every* ionizing particle passing through cylinder walls. (For a given isotope at a given distance from the counter, the count per unit time is a measure of the amount of the isotope present. Extremely small quantities can be measured. Since radiation is a random phenomenon, it is necessary to count a sufficiently large number of disintegrations to insure that the probable error of measurement will be within the required limits of accuracy.)

background—residual reading of radiation-measuring instrument due to (1) cosmic radiation, (2) slight radioactive contamination of the instrument, and (3) presence of extremely small amounts of radioactive materials other than those under study in the vicinity

half-life—time required for half the atoms in a given sample to decay. (Thorium has a half-life of several billion years; boron 12, a small fraction of a second.)

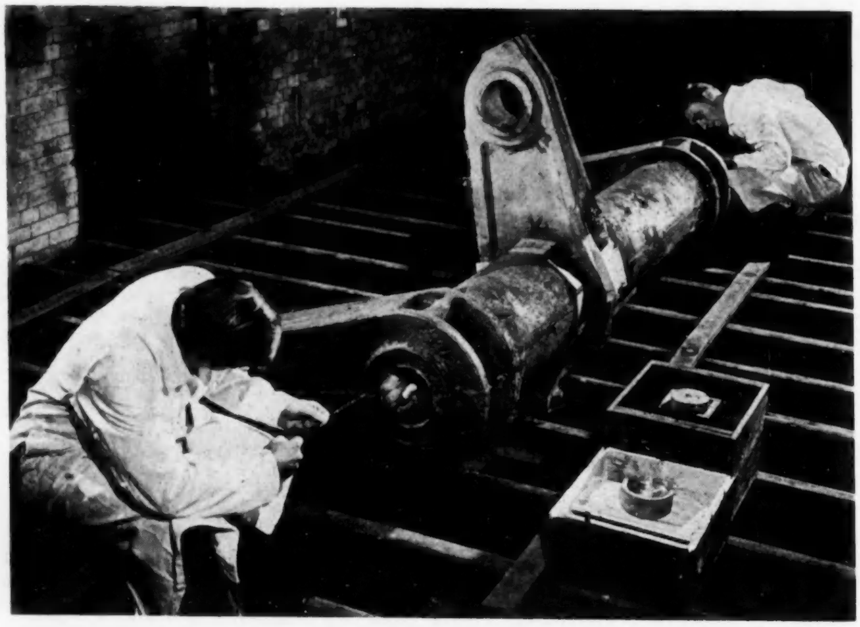


Fig. 1—Two technicians prepare large casting for radiographic inspection

other elements may mask effects of the isotope to be studied.

2. Half-life may be so short that the specimen loses its useful activity before the test or so long that there will be too few disintegrations for the required accuracy.

3. Wanted isotopes may not be formed in sufficient relative abundance.

Where the first method, compounding with radioisotopes, is used, either naturally occurring or manufactured isotopes can be used.

The natural radioisotopes are almost all heavy elements of atomic number greater than 80. They include isotopes of bismuth, lead, radium, uranium, and thorium. Radioisotopes of other elements are produced by subjecting matter to intense beams of fast protons, neutrons, alpha particles, or hydrogen nucleuses from cyclotrons or atomic piles. The Atomic Energy Commission distributes radioisotopes of many elements produced at Hanford and Oak Ridge.

Basis of Technique

Two facts make the tracer radioisotope technique possible:

1. All isotopes of a given element behave the same chemically. When a minute quantity of a radioisotope for tracing purposes is added to a quantity of a stable isotope of the same element, both isotopes

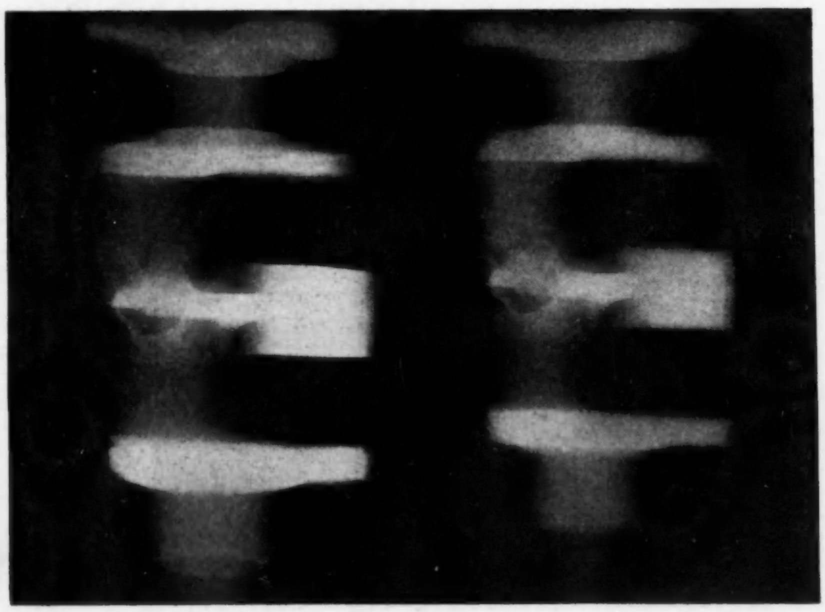


Fig. 2—Radiographs of crankshaft, left radiograph taken by means of cobalt 60 and right radiograph with X-ray machine

and their mixture have the same chemical properties.

2. Presence of radioisotopes can be detected and their concentration measured due to their radiation.

Here are some tried or suggested applications of radioisotopes in metallurgical work:

Iron 59 is being used to (1) study self diffusion of solid iron, (2) trace the diffusion and crystallization of iron in aluminum-nickel alloys, (3) investigate the magnetic domain of aluminum-nickel alloys, and (4) study corrosion.

Chlorine 36 is being used in a study of chlorine absorption in stainless steel from salt solutions.

Radioactive phosphorus added to the charge of a Bessemer converter, it has been suggested, could show when the last of the phosphorus (which is usually the last impurity) is being smelted from the steel. Automatic controls actuated by geiger-counter instruments could turn down and shut off the Bessemer when the radioactivity of the melt indicated proper phosphorus concentration.

Sulfur 35 served in an experiment designed to disclose the principal sources of sulfur in coke. Researchers knew that sulfur exists in coal in pyritic, organic, and sulfate forms. So they compounded some iron pyrites with radioactive sulfur, mixed them thoroughly with a coal charge, and coked the mixture in a full-scale coke oven under normal conditions. Then they determined the quantity of the radioactive sulfur evolved in the gas and the quantity remaining in the coke.

By comparing the quantity of radioactive sulfur in the coke with the total sulfur content of the coke, they learned that both pyritic sulfur and organic and sulfate sulfur are carried over from the coal to coke in equal proportions. There is no advantage in using coal with a low content of one type and a high content of the other.

Carbon 14 traces diffusion of carbon in pure iron in current studies of aging. With the same radioisotope, researchers are attempting to set up autoradiographic methods for studying the distribution of carbon in iron and steel.

Cobalt 60 Competes With X-Rays

Cobalt 60, a high-energy source of gamma rays, may also prove useful for radiographic work. Fig. 1 shows a large steel casting being prepared for radiographic examination. Fig. 2 shows on the left a radiograph of a crankshaft taken with radioactive cobalt and on the right a radiograph taken with radiation from a 1-million-volt X-ray machine. Examination of heavy castings is entirely feasible with cobalt 60.

The Ford Motor Co. jobbing foundry has found another use for cobalt 60. As Fig. 3 shows, the radioisotope in a protective housing has been installed just below the tuyere of a 60-in. cupola. Opposite the cobalt is mounted a geiger counter. Presence of liquid metal interrupts the beam to the counter. The signal from the counter is transmitted to indicating lights on the girder.

Knowledge of the liquid-metal level makes possible closer control and more efficient, more economical operation.

Fig. 3—Pilot installation of cobalt 60 (indicated by arrow at left) and geiger counter (indicated by arrow at right) on cupola at Ford jobbing foundry. When level of liquid metal falls below cobalt, counter picks up radiation

SIX SHAFTS for Remote

EXCERPTS FROM PAPER* BY

Hulon R. Shows

Project Engineer
Aircraft Accessory Drives, Power Transmission Shafts, and Gear Boxes
AIR MATERIEL COMMAND

FLEXIBLE-joint shafts are a light-weight, reliable means of driving aircraft accessories distant from but powered by the propulsion powerplants.

Modern aircraft require so many power-consuming accessories and modern engines can afford so little space for mounting them that it is becoming impractical to mount all the accessories directly on the engines. The trend is toward locating accessories not necessary to the engine—such as the generator, alternator, hydraulic pump, and air compressor—at a distance from the engine and driving them remotely.

Remote location of accessories has these advantages:

1. Reduction in the overhang moment on the engine decreases engine strength requirements and can reduce engine weight.
2. Tooling costs on engines will be lower because fewer engine models will be needed. A model with a standard power take-off (either mechanical or pneumatic) adequate for driving all required accessories can serve in various aircraft, despite differences in accessory drive requirements.
3. Fire hazard is decreased because possible electrical sparks are separated from possible fuel and oil leaks. Besides, fire-extinguishing agents are likely to be more effective in fighting accessory fires in closed accessory compartments.

Mechanical shafting is one way to drive accessories remotely. Other means for doing it are (1) hydraulic, (2) pneumatic, and (3) electrical systems; (4) auxiliary powerplants; (5) ram air turbines; and (6) release of high-pressure steam, bottled gas, or the products of a chemical reaction.

Reason for Choosing Shafts

Systems 1, 2, and 4 are under development. System 3 is currently popular but heavy. Systems 5 and 6 are now generally considered limited to short operating periods and used only on ramjets and rockets, respectively—although they may conceivably be used with other means of propulsion someday.

At present, flexible-joint shafts have the edge

Table 1—Requirements for Aircraft Accessory Drive Shafts

The input mounting flange and output mounting flange and drive must conform to AND 20002 or AND 20006.

Maximum Continuous Torque, lb-in.	1500 to 4200
Intermittent Torque, % of maximum continuous (for 5 min)	150
Static Torque, % of maximum continuous	450
Normal Rated Speed, rpm	7500
Overspeed, rpm	10,000
Maximum Altitude, ft	60,000
Altitude Change, in. Hg per sec	1.0
Maneuver Forces, g (sustained for 3 sec)	10
Position	All possible
Lubrication	ANA Bulletin No. 275
Temperature Range, F	−65 to 200
Total Maximum Misalignment, deg in any direction	5
Torsional Vibration, amplitude in deg (at 150 cps)	±2
Length of Nonsupported Shaft, in.	4 to 36
Contraction and Extension Thrust, lb per lb-in. of intermittent torque rating	0.05
Weight, lb per 1000 lb-in. per in. length	0.005
Polar Moment of Inertia to be Driven, lb-in.^{2}	50 to 386

* Paper "Driving Aircraft Accessories Remotely from the Aircraft Engine" was presented at SAE Annual Meeting, Detroit, Jan. 11, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Driving Aircraft Accessories

over other transmission systems in the matters of weight and reliability. While components for other transmissions are being perfected, shafts are likely to be widely used. They may always be best from the weight standpoint for certain uses.

Table 1 shows the requirements for aircraft accessory power-transmission shafts. Six proposed designs follow.

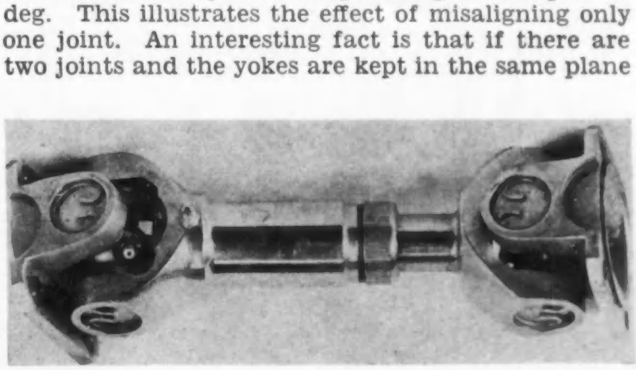
1. Spicer Flexible Joint Shaft

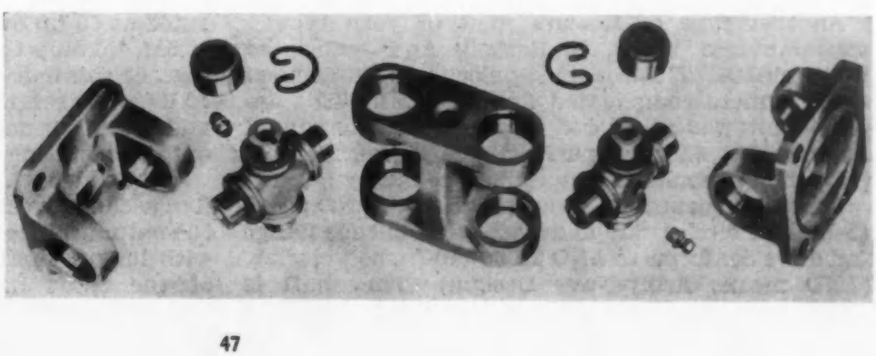
The most common type of shaft being used in aircraft today is made by Spicer Manufacturing Division of Dana Corp., Toledo, Ohio. This shaft employs the Hooke's joint (sometimes called the Cardan joint) and consists of two yokes at each joint to take the misalignment.

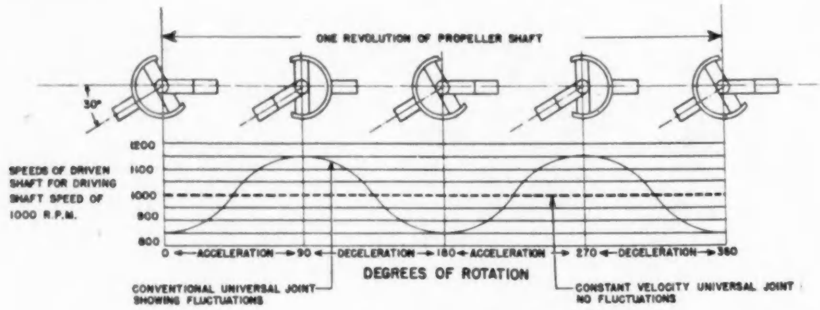
The shaft shown was designed for continuous torques up to 1500 lb-in. at 7500 rpm and has completed 500 hr of testing misaligned up to 3 deg transmitting 500 lb-in. This joint employs a sliding spline to allow longitudinal motion.

A Spicer shaft has been used between two adapters changing a rotating-flange drive to a spline drive. Such an assembly was built by Victory Engineering Corp. Experience indicates that better service life is obtained with the bearings if the joint is slightly misaligned, thus keeping the bearings rotating and preventing brinelling. Grease conforming to Specification AN-G-25, which is for a high- and low-temperature grease, has been found to perform satisfactorily if the bearings are relubricated every 100 hr.

The main disadvantage of the Hooke's type of flexible joint is the torsional vibration introduced by the shaft if the faces are not parallel. The torsional vibration (acceleration and deceleration of the shaft twice in each revolution) is illustrated by the graph, which shows the joint taking misalignment up to 30 deg. This illustrates the effect of misaligning only one joint. An interesting fact is that if there are two joints and the yokes are kept in the same plane

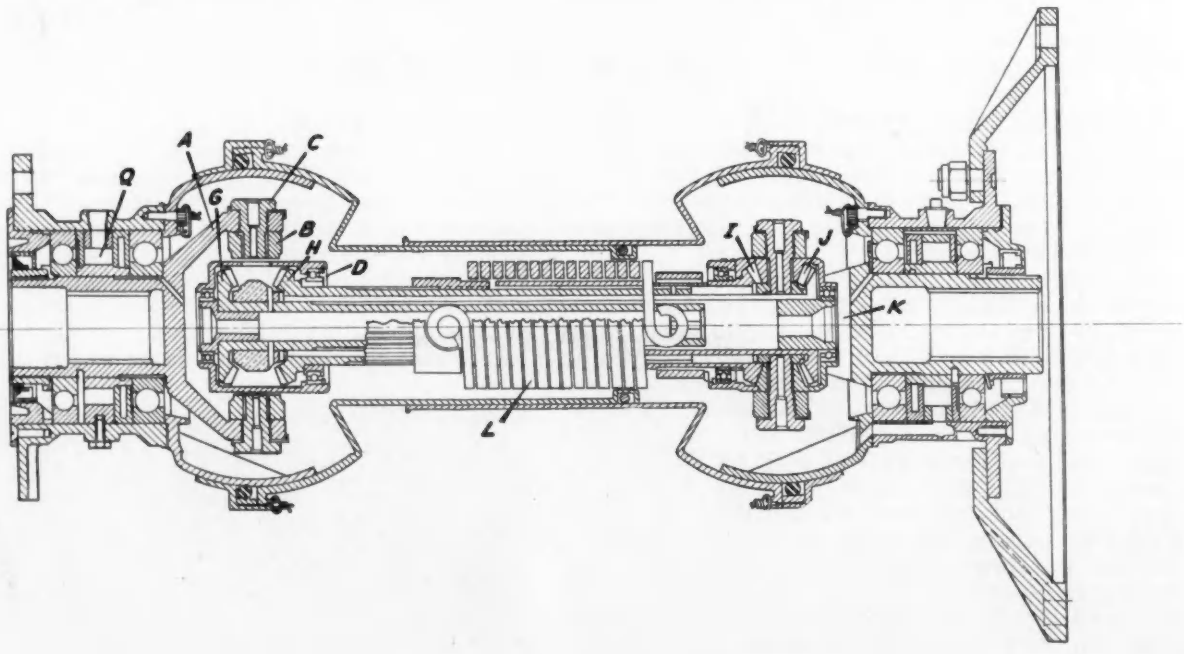






and the faces of the driven and driving end are parallel, the torsional vibration introduced by one joint is cancelled by the other joint. However, if the yokes are not in the same plane, the vibration is amplified, and if the faces are not parallel, vibration results. Advantage is deliberately taken of these features to introduce torsional vibration for aircraft accessory test purposes to stimulate the torsional vibration that is encountered with aircraft engines.

2. Szekely's Constant-Velocity Hooke's Joint Shaft



Another type of Hooke's joint or yoke type is manufactured by O. E. Szekely and Associates, Philadelphia. This constant-velocity shaft, employs a much more complicated flexible joint. This development was sponsored by the Navy Bureau of Aeronautics, and the performance is considerably greater than could be required of the Spicer joint.

The input mounting flange mates with AND 20002 (5-in. bolt circle) flange drives. The output flange and drive conforms to AND 20006 (10-in. bolt circle). (AND means Army-Navy Design.) The shaft is rated at 60 hp over the speed range 4000-6000 rpm. It can take up to 20 deg misalignment between the axes of rotation of the input and output splines or 10 deg between the axis of rotation of either spline and a line connecting the centers of the input and output mounting flange.

Nominal length is 18 or 36 in. The input mounting flange can move 2 in. in any direction with respect to the output flange and drive. The shaft may be used with longitudinal axis in any direction. Each end of the shaft has a double-acting pump which

scavenges each end and also supplies lubrication.

A separate oil tank of about 6-qt capacity is used with the shaft.

The drive is as follows: Input fork *A* drives ring *B* through trunnion pins *C*. The ring drives the differential housing *D* through trunnions fastened to ring *B*. The drive from the trunnion to the differential housing is by means of a pinion, which is free to move on the trunnion. The pinion then drives both side gears *G* and *H*, which are connected to side gears *I* and *J* at the input differential housing. The flow of power through the second differential is the reverse of the first, finally resulting in the drive of output shaft *K*.

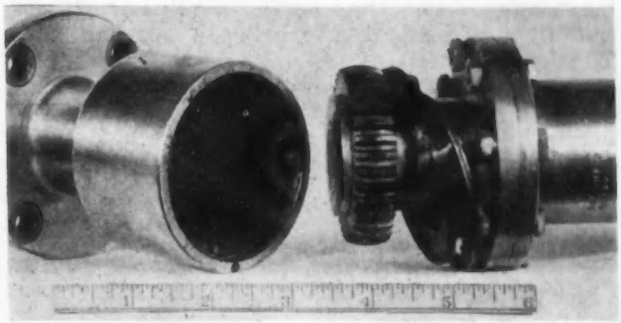
Side gear *G* is spline connected to side gear *J* while side gear *H* is connected to side gear *J* by means of torsional spring *L* which functions as a soft connection carrying half torque and forms an absorber for torsional fluctuations.

The entire unit is housed in a ball-jointed housing. Circulating pump *Q* is located between the two bearings of the input and output housing.

3. Knebar Spherical Spline Joint Shaft

This spherical spline joint takes misalignments up to 3 deg in each direction or a total of 6 deg in both directions. The shaft was designed for 100 hp from 3000 to 9000 rpm, misaligned 3 deg. The length is 36 in. and can extend and contract 0.5 in. It is lubricated by packing grease around the gear teeth. This shaft is also essentially a constant-velocity shaft. The shaft was designed by Couplings, Inc., Baltimore, Md.

Basically the shaft consists of a cylindrical tube between two spherical splines. The 34 external teeth or splines, of 2.125-in. pitch diameter, are spherically involute with a spherical radius of 0.625 in., whereas the internal teeth are regular involute splines. This allows the external spline to roll and slide in the internal spline to take the misalignment.

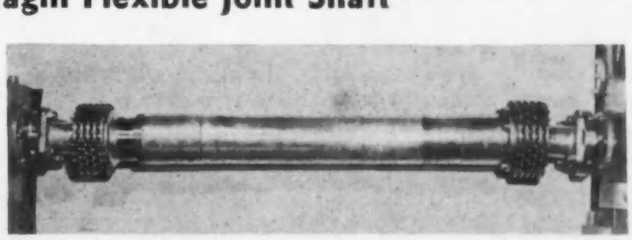


This type shaft may offer an advantage in that the standard spline within the engine may be able to serve as the internal spline.

4. Eclipse-Pioneer Diaphragm Flexible Joint Shaft

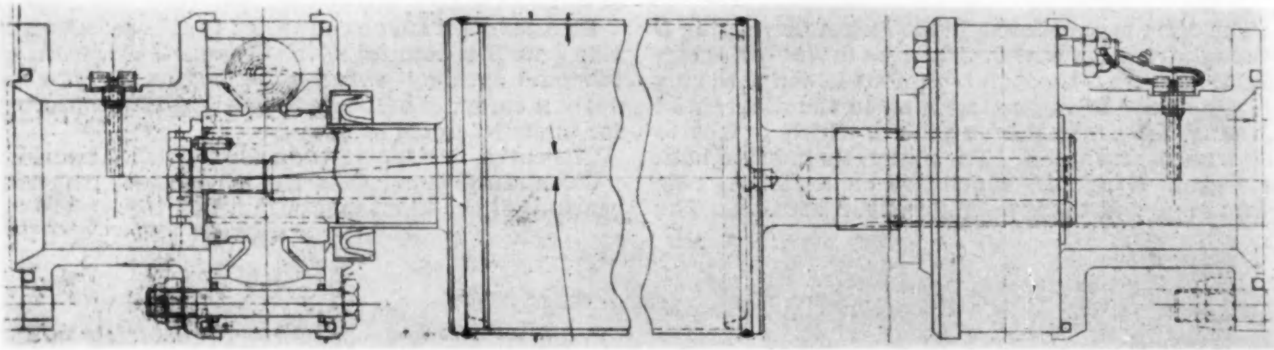
The Eclipse-Pioneer universal drive shaft, developed by the Eclipse-Pioneer Division of Bendix Aviation Corp., Teterboro, N. J., is a high-speed flexible coupling, one design of which has been operated continuously at loads up to 300 hp, speeds up to 9000 rpm, angular misalignment up to 4 deg, and variation in axial length up to 1¼ in.

The shaft consists basically of two constant-velocity flexible joints splined to each end of a long quill shaft. Each of the joints is made up of four thin, circular, dual-flanged members whose planes are normal to the torque axis with zero misalignment and in which angular displacement of the joint is obtained by resilient diaphragm flexure. Since there is no energy loss due to sliding or rolling friction in the torque transmitting member, the coupling should be inherently efficient and free from wear. The profile of the flexing diaphragms is hyperbolic and so designed as to provide for substantial uniform torsional and bending stresses



across the entire working area. Each end is equipped with a grease-packed ball joint whose function is two-fold: Under normal operation, the joint merely wobbles about the ball which serves to provide the desired radial stiffness. In the event of a diaphragm failure, the shaft will fail safe since the joint will be constrained to rotate about the wall. Thus, while transmission of power would cease, the shaft would continue to float on the balls for the duration of operation.

5. Rzeppa Ball-Type Joint Shaft



Another flexible joint being considered for aircraft use is the Rzeppa constant-velocity flexible joint shaft. This joint is made by the Gear Grinding Machine Co., Detroit, Mich. The shaft consists of a cylindrical tube between two ball joints. The joint consists of an outer driving member, of cylindrical or spherical shape; an inner, star-shaped driving member; and a ball cage closely fitted between inner and outer drives. Assembled into a concentric arrangement, these parts are interlocked and will swing relative to each other much like a ball-and-socket joint.

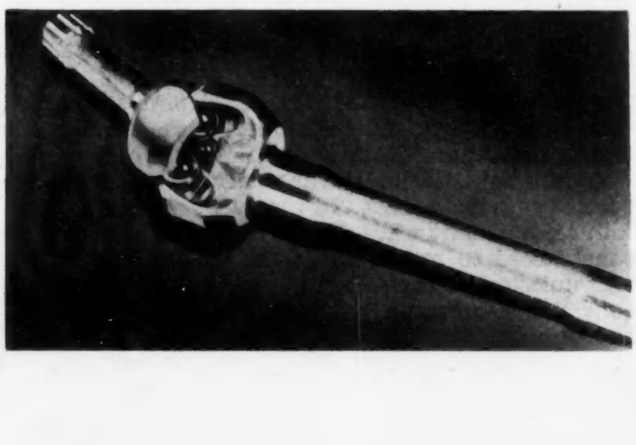
Each of the six balls, inserted in corresponding half grooves of both drives, transmits torque from one member to the other by free rolling action in closely fitted grooves.

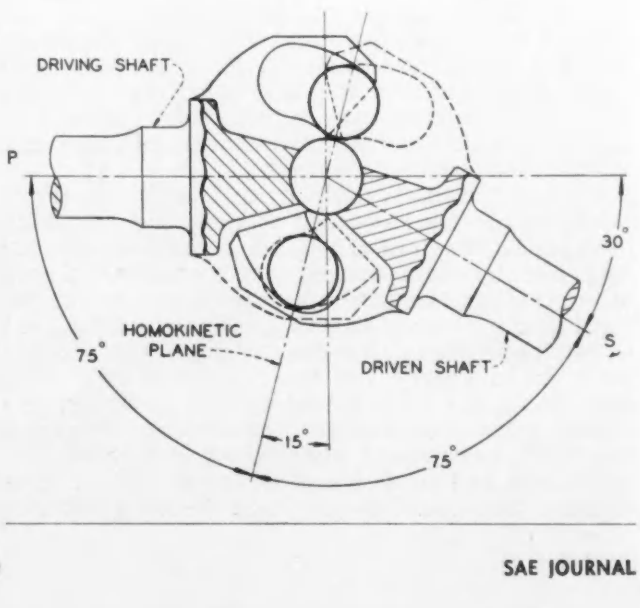
The rating of the shaft is 300 hp up to 9000 rpm with misalignment up to 3 deg and 1 in. linear movement, the linear movement being taken by sliding splines.

6. Bendix-Weiss Ball Type Joint

Another ball type of flexible joint being considered for aircraft use is the Bendix-Weiss constant-velocity shaft manufactured by Bendix Products Division, Bendix Aviation Corp., South Bend, Indiana. Although no data are available for high-speed applications, the shaft has proved itself at lower speeds and high working angles.

The joints have been used for transmitting propeller power to a remotely driven propeller and operated at 20 deg misalignment. As in the Rzeppa joint, the torque is transmitted through balls. In the Bendix-Weiss universal joint, the driving and driven contacts occur in the plane that bisects the shaft angle so as to transmit identical angular displacements from one shaft to the other. This is achieved by machining curved mating races for each ball into the two opposing yokes so that their center lines intersect, thus determining one definite location of this ball. Another characteristic of this joint is its provision for end motion within the joint itself. This is achieved by allowing the drive balls to roll back and forth in the races.





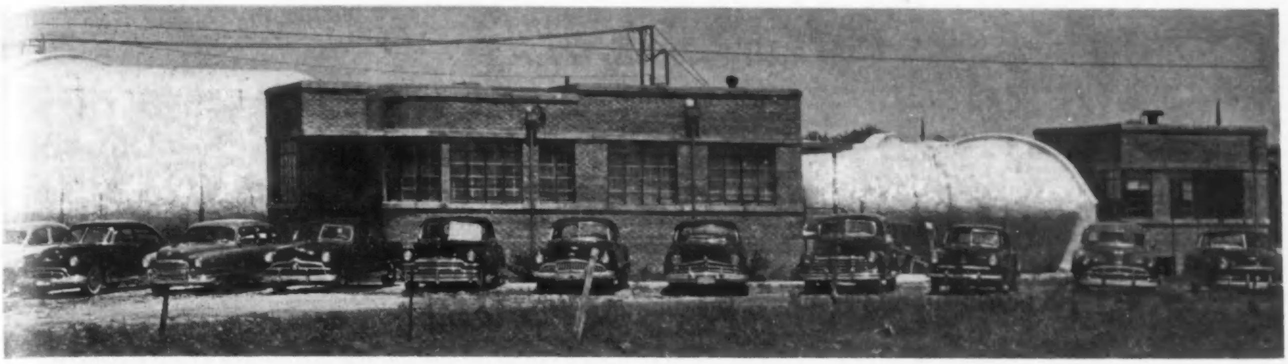


Fig. 1—The wind tunnel at the University of Wichita with some of the 1949 passenger cars tested in it for air drag. Control room and test area of the tunnel are in the center. A four-bladed propeller behind the 7 × 10-ft test section blew air over and around the car at speeds of from 30 to 85 mph. The 1000-hp engine which powers the propeller is in the housing at right

Wind Tunnel Tests Reveal CAR AERODYNAMICS

BASED ON PAPER* BY

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University of Wichita

(This paper will be printed in full in SAE Quarterly Transactions.)

ELEVEN 1949 cars checked in the University of Wichita wind tunnel (see Fig. 1) and correlated with road tests brought to light these facts about air drag:

1. Average air drag power at 60 mph was 22.4 hp, with difference between poorest and best over 50%.
2. Air drag equalled calculated rolling resistance due to tires and bearings at an average of 43.5 mph.
3. At 60 mph, as much as 64% of total engine power developed was used to overcome drag, and at 80 mph the maximum was 73% of engine power.
4. Shape of the car's rear end can be a big contributor to air drag. Notch-back cars had higher drag than cars with the slipstream type back.
5. Shielding front wheels reduced drag 1 to 2%, while streamlining the car underside decreased drag by 6%.

Air drag measurements taken in the wind tunnel were correlated with calculated air drag from road tests. Ratio of calculated drag to tunnel drag at the same speed gave a reduction factor of 0.57, applicable along the drag curve.

Using the 0.57 tunnel reduction factor, air drag at 60 mph ranged from 113 lb for the Nash Ambassador to 171 lb for Car I. (See Table 1.) This 58-lb range represents over 51% increase in drag from the lowest to the highest. Same percentage applies to any other speed, irrespective of tunnel reduction factor.

Average of the first 10 cars tested showed 22.4 hp required for air drag at 60 mph, with the range from 18.1 to 27.4 hp, as shown in Table 2. The car with the lowest drag was 20.7% better than the average, based on the first 10 cars tested in the wind tunnel.

* Paper "The Automobile . . . Moving People Through Air," was presented at SAE Metropolitan Section, New York, Jan. 19, 1950, and SAE Wichita Section, Feb 16, 1950. (This paper is available in full in photolithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Table 1—Air Drag in Pounds

Car	Miles per Hour 30	40	50	60	70	80
Nash Ambassador	30.0	50.2	78	113	156	205
Car A	33.3	59.3	93	133	182	238
B	31.2	52.7	82	118	161	210
C	33.0	59.0	92	131	178	232
D	35.0	60.3	94	136	185	240
E	35.0	60.3	94	136	185	240
K	33.0	61.0	96	139	190	250
Average (11 cars)	35.3	62.2	97	140	191	249
F	36.6	65.1	101	146	199	260
G	37.8	67.1	105	151	206	269*
H	41.0	73.0	114	164	223	292*
I	42.8	76.0	118	171	233	304*
	Values taken from smoothed curves to eliminate minor deviations in scale readings.					
Average drag in lb (10 cars) Exclusive of Nash	35.9	63.4	98.9	142.5	194.2	253.5

* These cars became erratic on the scales due to aerodynamic disturbances at speeds above 70 mph. In these cases the 80 mph values were extrapolated, as shown.

In comparing rolling resistance and air drag curves for each car, the two values become equal at speeds ranging from 40 to 50 mph. The average was 43.5 mph. This gives an arbitrary speed above which air drag can be considered the major power-consuming factor. Air drag increases about as the square of the speed, while rolling resistance increases at a lesser rate.

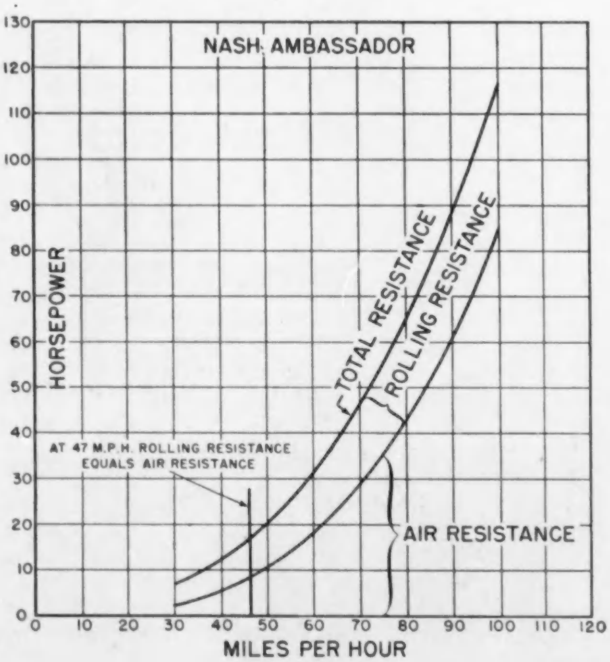


Fig. 2—Upper curve indicates total engine power at flywheel required to propel the Nash Ambassador at uniform speed. Above about 47 mph, air resistance represents the major portion of power required, as shown by the lower curve

For example, rolling resistance at 90 mph is about twice that at 30 mph. But air drag is nine times as great at 90 as at 30 mph. Therefore, air drag becomes important at high speeds.

As a case in point, the Nash Ambassador's air drag represents 58% of the total required engine horsepower at 60 mph, and 66% of engine power is used to overcome air drag at 80 mph. See Fig. 2. Other cars ranged as high as 64 and 75% for proportion of required engine power to overcome air drag at 60 and 80 mph, respectively.

Drag Reduction Boosts Mpg

Less power required to drive the car means more miles per gallon. In the Nash Ambassador at 60 mph, about 2.2 hp is saved in air drag—equivalent to 1 mpg in fuel economy. This factor probably varies considerably in other cars.

Tests on the 1946 and 1947 Nash sedans showed that these models had drag characteristics close to the top of the "spectrum" for the industry's 1949 models, as shown in Fig. 3. There is a slight advantage in favor of the 1946 Slipstream back design, as compared with the 1947 Trunk back model.

The comparison of drag between 1946-7-8 and 1949 models of the same make is rather startling. Reduction in drag for 1949 is directly responsible for the increase in maximum speed—7 mph.

No Progress in 17 Years

By contrast, checks made for one of the 1949 cars having relatively high drag characteristics showed practically the same drag when compared with tests on a 1932 sedan by the same manufacturer.

Aerodynamic efficiency of the car moving through air is expressed by the drag coefficient. This term

Table 2—Air Drag in Horsepower*

Car	Miles per Hour 30	40	50	60	70	80
Nash Ambassador	2.4	5.4	10.4	18.1	29.1	43.6
Car A	2.7	6.3	12.4	21.3	34.0	50.8
B	2.5	5.6	10.9	18.9	30.0	44.8
C	2.6	6.3	12.3	21.0	33.2	49.5
D	2.8	6.4	12.5	21.7	34.5	51.2
E	2.8	6.4	12.5	21.7	34.5	51.2
K	2.6	6.5	12.8	22.2	35.4	53.3
Average (11 cars)	2.8	6.6	12.9	22.4	35.6	53.1
F	2.9	6.9	13.5	23.4	37.2	55.5
G	3.0	7.2	14.0	24.1	38.5	57.3
H	3.3	7.8	15.2	26.2	41.7	62.3
I	3.4	8.1	15.7	27.4	43.4	64.8
Average hp (10 cars) Exclusive of Nash	2.86	6.76	13.18	22.79	36.24	54.00

* Values computed from air drag data in Table 1, by the expression:

$$HP = \frac{Drag \times mph}{375}$$

reflects frontal area, air density, vehicle speed, through the air, and drag. The expression for it is:

$$C_d = \frac{D}{\frac{Density}{2} \times Area \times V^2}$$

where:

C_d = coefficient of drag,
D = measured drag in pounds,
V = air speed in feet per second,
Area = frontal (maximum cross-sectional) area of car,
Density = mass density of air expressed as slugs per cubic foot.

Table 3 shows values for each car for frontal area, corrected drag at 60 mph, and coefficient of drag. In general, high drag cars also had a high drag coefficient. But Car A, with next-to-greatest frontal area, rated next to best for drag coefficient, but third from best for total drag. Cars B and C also "out of order" based on total drag. This variation in drag and coefficient characteristics among the four lowest drag cars seems to substantiate the method of test and correction factors used.

These wind tunnel tests also indicated that shape of the car rear end wields a major influence on drag. The gradually tapering rear end of the Nash, both in profile and plan view, materially reduces the area of turbulent flow behind the car. Air flow behind the Nash Airflyte becomes turbulent about one-third down the trunk lid, while in most cars—particularly those with notch backs—turbulent flow starts forward of the rear window.

Because of this turbulent flow, almost the entire cross-section of most cars is subject to lower static pressures, which act on the rear surfaces to increase drag. It is interesting to note that the six highest-drag cars were all of the notch-back type, while three of the five lowest-drag cars had the slipstream type back.

Front end shape also seems to be a source of drag. Checks on several cars indicate considerable variation in static pressure over a relatively large area around the grille. In a car with favorable rear-end

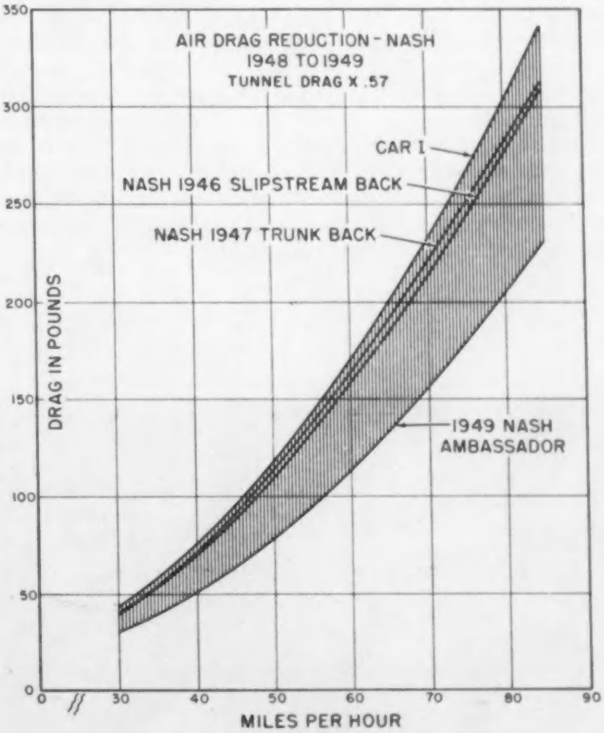


Fig. 3—The 1948 Nash, which had exactly same styling and characteristics as the 1946 and 1947 models, had air drag close to the high side of the range of all cars tested. The 1949 Nash, as indicated by the curve had the lowest drag of the cars tested

Table 3—Air Drag Comparison Summary

Car	Frontal Area sq ft	Drag in lb @ 60 mph	Coef. of Drag C_d
Nash Amb	30.9	113	0.43
A	33.4	133	0.47
B	27.5	118	0.50
C	29.9	131	0.51
D	30.9	136	0.52
E	30.4	136	0.52
K	30.4	139	0.54
F	31.8	146	0.54
G	31.0	151	0.57
H	33.1	164	0.58
I	33.6	171	0.60

styling, the static pressure over the front end may be the major factor contributing to total drag.

Lack of streamlining on the car's underside is often pointed to as evidence that designers streamline cars solely for appearance—not for air drag reduction. The Nash Ambassador was checked in the wind tunnel with a canvas shroud slung underneath, simulating nearly perfect streamlining. See Fig. 4.

The drag was reduced only 6.3%. This indicates that relatively little improvement could be achieved by this means, even if a practical and low-cost design could be developed.

Apparently the forward-most structure of the car determines the amount of air crowded down under the car. The air seems to split ahead of the car at bumper height. Most of the air goes over the top or flows around the sides, and relatively little flows underneath.

Several checks also were made to evaluate effect of shielding the front wheels. In some early tests a severe air-flow disturbance was noted around the fender openings of some cars. Masonite fender-opening covers were provided for several cars to see if a difference in total drag could be detected. Even though tested on entirely different makes of cars, an improvement ranging from 1 to 2% was measured when these shields were installed.

Two cars had exterior accessory sun visors when delivered to the wind tunnel. Both cars were tested with and without visors. A difference of about 9% was measured in each case. At 60 mph, these visors cost the owner from 2 to 3 hp, or about 1 mpg in a Nash.

During the tunnel tests, two cars gave puzzling vibration on the scales. Vibration, at a rate of about 3 or 4 cps, could easily be felt when sitting in the car, particularly in the rear seat. Complete tunnel tests were not made above 73 mph on these two cars because of the erratic effect on the scale mechanism. Oil was thrown out of the dash pots and accurate drag measurements became impossible.

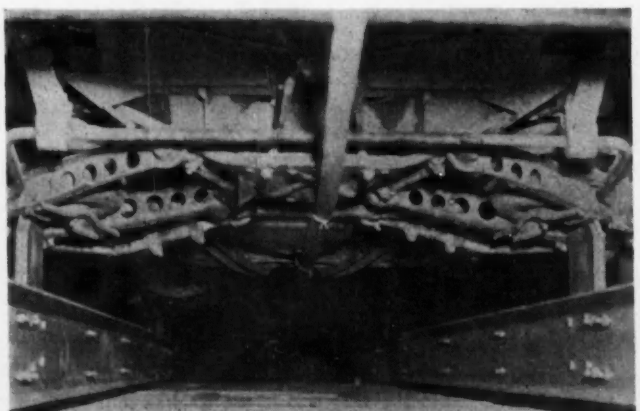
The turbulent flow which occurs over the rear of cars produces an oscillating pressure pattern. The greater the degree of turbulence, the greater the amount of vibration produced. The resulting vibration characteristics probably are affected by flexibility of tires, suspension, and chassis frames.

This aerodynamic vibration, noted on the same two cars on the road at the same speeds, may be important only as it contributes to driver and passenger fatigue. Any aerodynamic drag reduction in car bodies will likely reduce the turbulent pattern correspondingly. And it will reduce—if not eliminate—the vibration noticeable inside the car.

Power for accelerating and hill climbing is available only from the difference between engine power and total car-driving power at any speed. Historically the automotive industry has increased this "performance" part of total available power by packing more horsepower into the engine at the expense of fuel economy.

It would seem more scientific to provide adequate performance by reducing total car-driving horsepower. Most promising way of doing this is by reducing air drag. This approach also would improve fuel economy, passenger comfort, high-speed performance, and reduce wind noise.

(The paper also tells how air drag computations were made from the observed measurements and how wind tunnel drag was correlated with road test values. It describes the wind tunnel and test setup.)



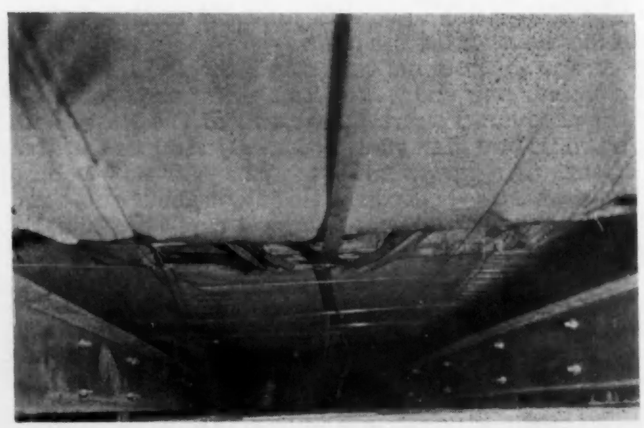


Fig. 4—Under body of the Nash Ambassador, at left, was streamlined by covering it with a canvas shroud at right. Wind tunnel tests showed that this reduced air drag only 6.3%

Discussion

Wind Tunnel Test Results Compared with Other Data

Based on discussion by

P. H. Pretz

Ford Motor Co.

Difference in air drag observed between notch back and fast back cars as well as the wind tunnel technique itself is open to discussion.

Data obtained with a wheel torque meter (used for measuring car speed and torque), shown in Fig. A, compares the 1948 Ford sedan in the fast-back style with the 1949 Ford sedan of the notched-back style. Note that our results parallel those of the comparative Nash models in that our 1949 model also showed a decided increase in maximum speed, with no additional engine output. But this was achieved despite the fact that we had reversed Nash's change in body styling, since we went from the fast back to notch back.

The 1949 models of both makes of cars do have a definite decrease in frontal area. Frontal area measurements are made with a transit on the actual loaded vehicle and the area determined from a full-scale projection, excluding the area between varying treads and the lowest portion of the sprung mass.

Frontal area on the 1948 Ford was 28.8 sq ft, and on the 1949 model, 25.4 sq ft. Area on the 1948 Nash was 28.5 sq ft, and on the 1949 Nash, 26.8 sq ft.

Because of the parallel results with the reverse change in body style, but similar trend in reduction of frontal area, we are inclined to put more emphasis on frontal area than rear-end contour of the body as affecting drag.

This is further illustrated by Fig. B, which shows practically no difference between road power requirements of the Lincoln Cosmopolitan fast-back and notch-back models, as measured on the road with the wheel torque meter. Remember that these models are identical in weight, tire size, chassis construction, and frontal area.

There also seems to be some question as to the accuracy of the drag load measured if this load must be reduced 43% to represent road conditions. It is believed this large correction may be necessary because of much higher velocities past the car (which takes up about half the tunnel area) than the velocities measured in the free air stream ahead of the car.

It also seems that even under these conditions the drag loads are given a lineal instead of a square correction, which of course erroneously magnifies the differences at the speeds shown.

Road load horsepower can be closely calculated up to 80 mph using weight and frontal area with the same coefficients, regardless of present day streamlining. Considering equivalent performance, frontal area, and customer average driving speeds, the economic difference in fuel saving from existing types of streamlining is considered very small.

A most promising means of improving performance and economy at higher speeds is by reducing air drag. Wind tunnel work should be a reliable and relatively quick method of achieving improvements. It is suggested that accurate correlation of tunnel and road results be established first. This may imply using larger wind tunnels or scale models.

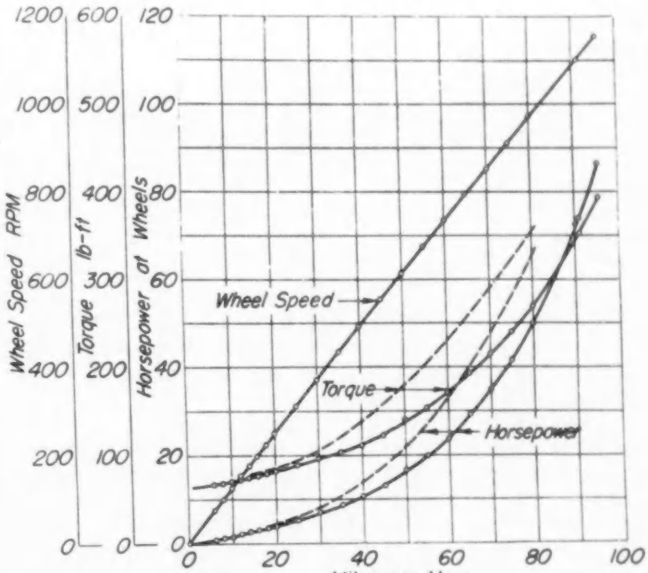


Fig. A—Wheel torque and power requirements, measured with a torque meter, shows an increase in top speed for the notch-back 1949 Ford (dotted lines) compared with the fast-back 1948 Ford (solid lines). This gain is attributed in a large measure to reduction of frontal area

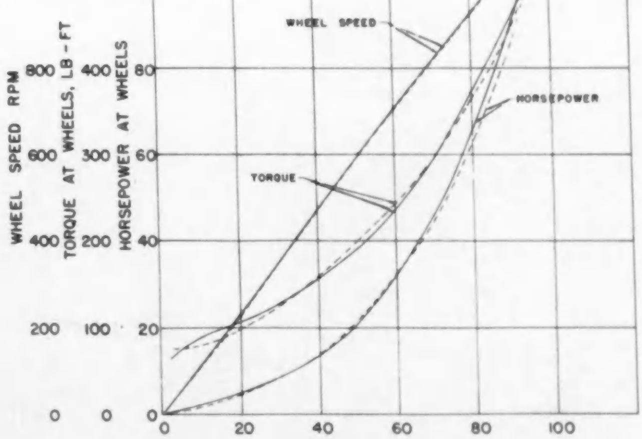


Fig. B—Little difference was found in road-load power requirements of the fast-back Lincoln Cosmopolitan, model 73 (solid line), compared to those of the notch-back Lincoln Cosmopolitan, model 73 (dotted lines). Both these 1949 cars are exactly alike, except for rear-end styling. These data indicate that rear-end styling has little effect on air drag

Airline Operator's Verdict:

THERMAL ANTI-ICING

THERMAL windshield and wing anti-icing are here to stay, on the basis of their performance in the DC-6 and Convair 240, despite some current drawbacks.

Pilots like the added assurance of clear windshields and ice-free wings that stems from use of heat instead of the older fluid and pneumatic means. Designers and maintenance men are overcoming the new service troubles related to heated surfaces. And management is receiving encouraging reports of downward trends in operating costs.

Windshield Deicing

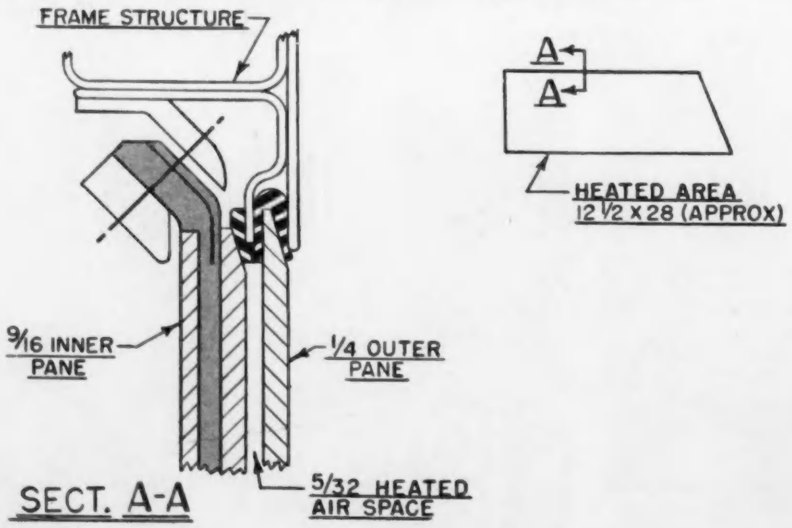
DC-6—The heated-air method of deicing has been giving good results. It is reliable —as reliable as the cabin heater which supplies the heat.

The system requires little maintenance attention other than occasional removal of the dust that collects between the inner and outer windshield panels. Replacement of glass due to optical defects, scratches, or cracks is seldom needed. Only occasionally do birds or large hail stones shatter the outer pane and depressureize the airplane. (The inner, birdproof panel has never permitted a colliding bird to penetrate the cockpit of a DC-6.)

Cost of windshield deicing is estimated to be less than 10¢ per hr of flight.

One difficulty with the system is that it can fog the windshield during rapid descents from high cold altitudes into lower strata of moist warm air. The cold glass and metal surfaces condense large quantities of moisture. Because the moisture in the

DC-6 Windshield Deicing System



Air heated to a maximum of about 250 F by the cabin heater passes through the 5/32-in. air space between the two panes of the windshield. The outer pane is glass. The inner pane is a birdproof glass-plastic-glass sandwich.

IS HERE TO STAY

BASED ON PAPER* BY

M. G. Beard and **Dave North**

Director of Flight Engineering — Assistant Project Engineer, Aircraft Systems

American Airlines, Inc.

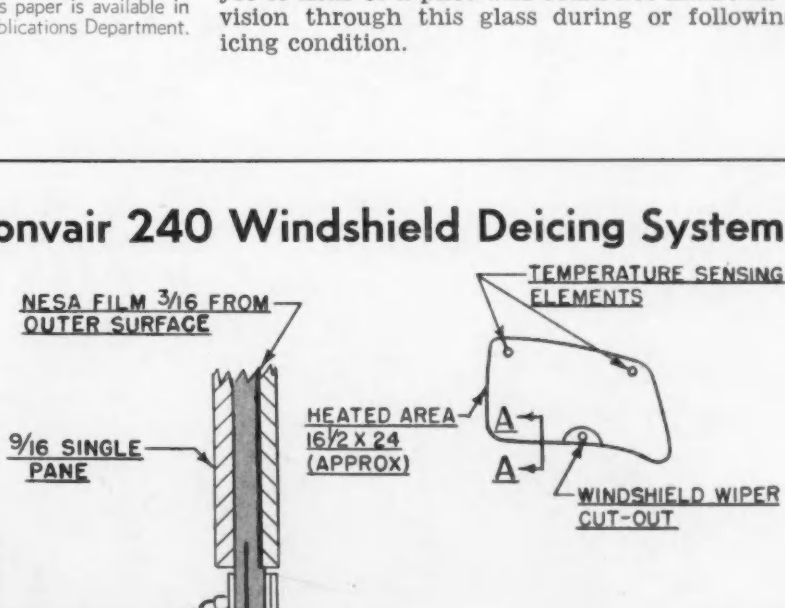
ducts leading to the windshield must be dried out before dry air reaches the windshield, defogging may take several minutes of hot-air blast.

Of course, perfect administration of windshield heat by the pilot can prevent fogging. But pilots tend to avoid using windshield heat because it dumps hot air into the cockpit and the airflow is noisy.

Convair 240—From a deicing standpoint, the single electricity-conducting pane forming the windshield has been a complete success. We have yet to hear of a pilot who could not maintain clear vision through this glass during or following an icing condition.

* Paper "Operational Results of Thermal Anti-Icing" was presented at SAE Annual Meeting, Detroit, Jan. 9, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Convair 240 Windshield Deicing System



A very thin film of metal lies between the outer layers of the glass-plastic-glass panel. Passage of a 325-v alternating current through the film produces heat. Thermistors (temperature-sensing resistance elements) control the heating.

The windshield pane is Pittsburgh Plate Glass Co.'s Nesa glass. (Libby-Owens-Ford is introducing Electrapane, a similar product.)

Pilots prefer the Nesa windshield to double, air-heated windshields because the Nesa heats faster and more uniformly to a higher temperature. Besides, the single Nesa pane cannot become fogged or dirty internally or present a double image at night. Chromatic aberration is noticeable from the outside but is never pronounced in any part of the windshield viewed from inside the cockpit.

From a maintenance standpoint, Nesa glass has proved costly to operators of the Convair, first production airplane to use it. In a 12-month period, American Airlines' Convairs averaged one replacement of a main or a direct-vision window for every 1500 hr of flight. Principle reasons for replacement have been (1) cracks due to thermal stresses, (2) disintegration of the Nesa film resulting in uneven heating or obstruction of pilot vision, and (3) overheating caused by failures of temperature controls.

Estimates show that replacement of a main window costs $175 for labor and $375 for material, replacement of a direct-vision panel costs $75 for labor and $150 for materials. Resultant overall operating cost of windshield deicing has been 35¢ per hr of flight.

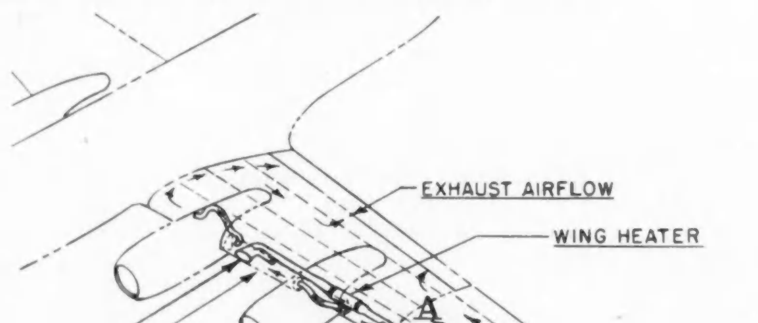
Frequency of breakage is now being reduced rapidly by changes in windshield shape and location of electrodes and thermistors.

Deicing benefits of electrically heated glass are so great that its development must continue. It is practically the only answer for future aircraft. Our advice to designers is to stick with electrically heated glass but make all such installations easy to remove. The glass, at least at present, cannot be expected to last the life of the airplane.

Wing Anti-Icing

Useful as the wing anti-icing systems of the DC-6 and the Convair 240 are, neither system supplies enough heat to leading edges to evaporate all moisture impinging on the leading edge under the most

DC-6 Wing Anti-Icing System



Each wing has its own independent system. Air enters through an inlet on the leading edge between the inboard and outboard nacelle and proceeds outward. A heater in the outboard nacelle heats the air to a maximum of 368 F, then discharges it to a spanwise distribution duct. Air at about 300 F is fed between the two skins at the leading edge, heating the metal to a temperature between 32 and 100 F under icing conditions. Wing surfaces are warm, not hot.

Output of the 350,000-Btu-per-hr gasoline combustion heater is controlled by cycling fuel injection. Dual controls, fuel systems, and ignition sources insure reliability.

severe conditions. When some moisture is left in liquid form, it runs back along the wing surface and may freeze there. These deposits cut down the aerodynamic efficiency of the wing.

Operating with one wing heated and one cold is not the hazard it was predicted to be, tests with both the DC-6 and the Convair 240 showed. The change in lateral trim is so gradual that the pilot has ample time to turn off the wing deicing system.

DC-6—With operations conducted so far, runback has not been especially severe. Nor was it severe under test conditions of liquid water content up to 0.60 g per cu m and 36 microns average droplet diameter at - 14 C for continuous exposures of 20 min.

Substantial deposits have appeared over the integral fuel tank, and minor deposits at the wing and stabilizer tips.

Whenever icing conditions are encountered, the DC-6 wing picks up ice along the leading edge between the fuselage and the inboard nacelle, where double-skin protection is lacking. At times, these deposits are of considerable thickness. They contribute to aerodynamic losses and may raise prestall buffeting speeds and cause tail buffeting at landing approach speeds. Besides, they are likely to worry passengers in front seats, who get a clear view of the inboard part of the wing.

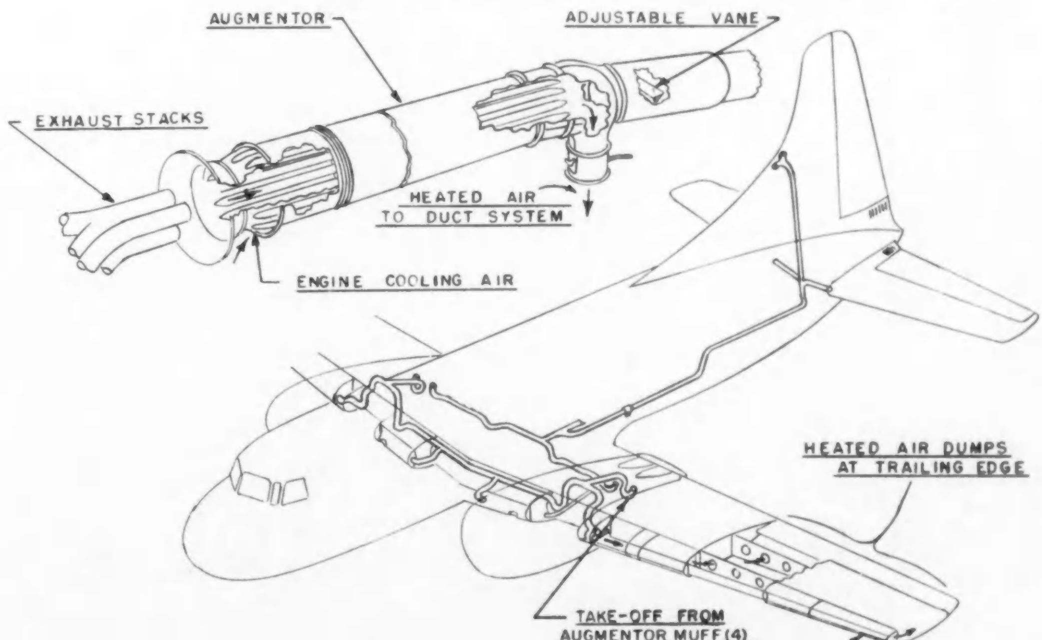
From a maintenance point of view, the combustion heater-plus-ducting system for anti-icing has at least two advantages over pneumatic deicer boots:

1. Wing ducting stands up from one 1200-hr inspection to the next. Repairs are largely preventive and can be scheduled at regular inspection periods.

2. Heated-air wing anti-icing systems withstand warm weather well. (Rubber deicer boots deteriorate most rapidly in the summer, when least used, partly because ground checks in static conditions overburden heat-limiting mechanisms.)

They also have two disadvantages:

Convair 240 Wing Anti-Icing System



Each of the Convair's two engines has two augmentors, which incorporate heat-exchanger tubes. Ram air enters the engine cowl, serves as engine cooling air, then passes into an augmentor. There, the air picks up heat transferred from the exhaust gases and attains a temperature usually between 350 and 450 F.

Each outboard augmentor sends air thus heated to its adjacent wing section. Spanwise ducts deliver the air to a thin passage between double leading-edge skins, where it performs its anti-icing function. It is finally exhausted at outlets along the wing trailing edge.

Outboard augmentors also deliver air to the inboard wing section and a cross-over duct to the opposite wing system. Purpose of the cross-over is to provide two-wing anti-icing during single-engine operation. Inboard augmentors supply cabin air heating and tail anti-icing systems.

1. Conclusive performance checks for heater output and distribution can be made only in flight.

2. A malfunctioning combustion heater or temperature-cycling device is a fire hazard.

One expected disadvantage has not materialized. Heating design engineers feared that the surfaces of the leading-edge passages might accumulate a film of insulating dust sufficient to lower heat transfer rates and cut down overall efficiency of the anti-icing system. To date, no such deterioration has been detected.

Cost of DC-6 wing and tail thermal anti-icing systems is estimated roughly at $1 per hr of total airplane flight or $16.60 per hr of flight in icing conditions. (The tail anti-icing system employs one combustion heating unit like those used in the wings.)

Convair 240—The Convair has developed wing and tail runback and ice in numerous moderate and severe icing encounters.

Runback has formed chordwise rivulets well back toward the trailing edge and substantial ridges of ice in the front spar area. During one test flight, clamps of ice on the underside of the wing were thick enough to be readily visible from the cockpit. Line crews twice reported similar conditions.

We believe runback on Convair wings could possibly develop enough drag to make single-engine performance critical. Our instructions to flight crews are to take evasive action whenever airspeed loss approaches 40 mph under cruising conditions, as greater airspeed loss means critical single-engine operation.

Although the Convair has a leading-edge heat duct between fuselage and nacelle, heat values are lower than in outboard ducts and ice often forms. Any substantial deposits are likely to produce buffeting on the stabilizer.

Wing ducting of the Convair, like the DC-6, is easy to maintain, but augmentors have given considerable trouble, as evidenced by the fact that augmentor design has been changed at least 11 times. The problem is to design heat exchanger tubes that can withstand the high temperatures and pulsations of exhaust gases.

Some tubes have failed after as little as 50 hr of engine operation. Other tubes have run 1000 hr. For a while, Convair operators found it necessary to replace each tube about every 400 hr, usually due to fatigue cracks in the inner shell. With such frequent replacements, costs of wing and tail anti-icing were estimated as high as $4 per hr of flight—or $80 per hr of flight in icing conditions—after deducting 40% of costs considered chargeable to cabin heating and increased airspeed.

Improvements in design raised the 400-hr figure to 800 hr. The goal is 2000 hr, which will bring costs down to around $1 or $1.50 per hr of flight, it is estimated.

Propeller Deicing

Electrical propeller deicing on the DC-6, Convair, and other current airplanes is of similar design and principle. Electrical power is obtained from the ship's generating system and is intermittently consumed by resistance heating elements on each propeller. Some designs position the heating element on the inside of a hollow steel propeller blade; others cement the element to the outside surface. Typical external heating pads are 40 to 52 in. in length, 5 in. in heated width, consume 140 to 200 amps per propeller at 28.0 v, and are intermittently heated about 24 sec "ON" and 72 sec "OFF".

As operated by American Airlines, both airplanes use essentially the same deicer shoes, and the same timing cycle. One would therefore expect their service life to be the same. It is not. Shoes on the DC-6 can be made to give satisfactory service for 1000 to 1200 hr; while on the Convair, the shoes do well to operate for 300 to 400 hr. The reason for this is that the DC-6 makes a landing every 120 min, mostly at the select airports, during which landing the inboard propeller tips clear the runway by a nominal value of 26 in. In contrast, the Convair is a short range "hedge-hopper" stopping every 50 min at airports generally equipped with less suitable runway surfaces. Most significant is the fact that Convair propellers clear the ground by only 11 in. To counteract this handicap, American Airlines is pursuing the development of a two-piece prop shoe, the inner 25-in. segment of which is a conventional wire grid element, while the outer 15-in. segment has an extra heavy leading edge designed to withstand severe abrasion and to be easily replaceable in the event of damage.

Our experience indicates that the following costs are present with electrical propeller deicing. For the DC-6, $ .70 per airplane hour or $ .175 for each of the four propellers. For the Convair, comparable figures are $ .88 per airplane hour or $ .44 for each of the two propellers. Note how much more costly is the upkeep of heating elements on the latter which is due entirely to the more severe abrasion pattern.

Excerpts from Discussion

—W. W. Reaser

Douglas Aircraft Co., Inc.

In operating DC-6 windshield heat defogging, pilots need not dump the hot air into the cockpit area. A control is provided which enables the pilot to allow the air either to pass into the cockpit or be exhausted under the cockpit floor. Only full airflow, passed through the windshield for de-icing, produces noise, and this is not severe when the windshield is maintained to keep leakage low. The "vinyl" setting (low airflow) is enough to prevent fogging. With this low airflow, our experience is

that the noise is low even though the windshield may be leaking considerably.

Designing the wing thermal anti-icing system so that no runback will occur is impractical. Predictions made on the amount of heat required have indicated approximately double the capacity of present systems would be necessary. Experience with runback to date does not warrant this additional capacity, with its attendant weight and complication.

It is believed that results of research now being carried out by NACA will not show need for complete prevention of runback. However, the results may indicate that some increase in capacity will be desirable.

Additional research and development on the combustion heater indicate that the operational cost of $1 per hr will be reduced in the future. Ground tests indicate that recent design changes made in the heater will increase its life. Final decision to change to heaters of the new design will have to await service testing in the airplane.

—R. C. Loomis

Consolidated Vultee Aircraft Corp.

American Airlines is to be congratulated on their continued operation of the electrically heated windshield panels so that new developments may be adequately tested leading to the eventual trouble-free operation of this type of windshield deicing. As a result of last winter's operating experience, developments now under way seem certain to assure low-cost operation of electrically heated windshields during the winter of 1950-51.

With regard to runback and refreezing of water on portions of the wing behind the leading edge, Convair tests indicate that this problem is not serious, even under the most adverse icing conditions, when the wing and empennage anti-icing systems are putting out the maximum available heat and the system is properly used. Convair experience is that runback will form in ridges of a serious nature when deicing is attempted under certain icing conditions, whereas the runback forms in chordwise rivulets if the heat is on full before entering ice. If sufficient ice is formed before turning on heat, the runback may be momentarily so severe that ridges are formed which will in themselves pick up ice accretion. Inasmuch as airline pilots have been experimenting extensively this last winter, it is believed that the serious ice runback formations reported in the paper have been entirely due to the improper use of the system.

The Convair Liner thermal anti-icing maintenance-cost data contained in the paper represent the first-year costs of radically new systems and do not reflect the effect of recent improvements. Convair has had under constant development for the last 18 months improved augmentor tubes which will not only increase the heat available for thermal anti-icing but which will stand up well beyond the 400-hr change period. These augmentor tubes are now being delivered in quantity to the airline operators, and we fully expect that all Convair Liners will be equipped with the improved tubes during next winter's operation with subsequent improvement in thermal anti-icing and substantial reduction of maintenance cost.

—Lewis A. Rodert

The failure of the heated-wing systems on the DC-6 and Convair 240 airplanes to prevent the formation of ice during flight in serious conditions indicates that a study should be made of the heat flow in the systems of these airplanes. An attempt should be made to measure the quantity of heated air produced by the heating source and the total pressure with which the air leaves the heater or exchanger. Next, the flow through the hot-air ducts should be examined for the purpose of discovering how much air is lost through leakage and what the pressure and temperature drops along the ducts are. Finally, the quantity of heated air and its temperature as delivered to the leading-edge double-skin system should be measured.

From such a study the operators may determine to what extent each component of the anti-icing systems is fulfilling the design specifications. Intelligent corrective measures which will eliminate the failures to prevent ice may be undertaken only after the causes for the malfunctions are known. It may be that when and if the full quantity of heat is properly distributed to the system, the failures will have been eliminated, and current interest in more accurate data on icing rates will be somewhat less justified.

Current efforts being made to obtain icing rates of a statistical nature should be continued, however, in order that a more comprehensive basis for anti-icing system design may be established.

The failures in augmentor tubes and other types of heat exchangers may be due to the growth of structural parts which undergo heating and cooling cycles. It was found in the early development work on heat exchangers that the corrugated-wall-type exchangers, when built in sizes about 150,000 Btu-per-hr capacity, would fail within a service experience of as low as 25 hr. It is believed that these failures were due to the expansion and compression of structural components beyond the yield point during the heating cycle and a similar overstressing of other components during cooling. These high cyclic stresses cause a growth and distortion of the structure which eventually result in a rupture of the exchanger wall. A cure for this type of failure may be found in structures which are free from excessive stresses during the heating and cooling cycles. Although increasing the gage of the metal may sometimes eliminate the difficulty, it is more probable that the solution will be found in a more favorable configuration, flexibility, or the freedom of adjoining components to slide upon one another.

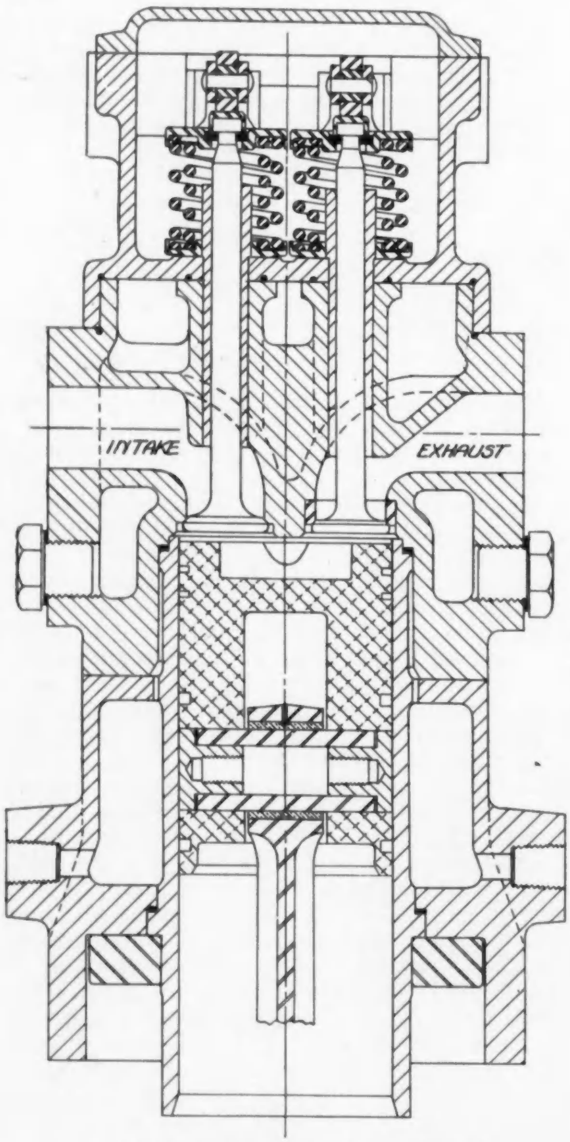


Fig. 1—Longitudinal section of "27 cylinder"

Variable Aids

(This paper will be printed in full in SAE Quarterly Transactions.)

THIS paper covers data obtained with a 3¼-in. bore × 3¼-in. stroke single-cylinder engine which was designed and built for exploration of compression ratio and other effects of interest in the passenger-car engine field. Fig. 1 shows a longitudinal section of the cylinder (known as the "27 cylinder"), which bears no resemblance to any existing passenger-car engine. Compression ratio and combustion-chamber effects on fuel economy and knocking have been extensively explored over a compression ratio range of 5.7 to 15.0 and over a speed range of 1200 to 3000 rpm. A limited investigation of knocking behavior was carried out at compression ratios of 21.3 and 30.

The intake and exhaust ports of the cylinder are so arranged as to produce a minimum of induction turbulence. Turbulence, in addition to that obtained with a flat-top piston and a normal intake valve, is obtained, firstly, by use of a shrouded intake valve and, secondly, by squish pistons. Squish pistons and a shrouded intake valve can be and have been used together. The squish pistons confine the majority of the charge within the piston crown, as shown in Fig. 1.

This paper, to a considerable extent, covers effects of combustion-chamber design. The authors are neophytes in the matter of combustion-chamber design and have confined themselves to expressing engine findings rather than opinions.

Appraisal of Data

All data are in terms of indicated performance, which is obviously necessary in this case since at 3000 rpm. and 10 in. of Hg absolute manifold pressure, friction mean effective pressure was about 80 psi and brake mean effective pressure about 50 psi. Every observation of dynamometer load was accompanied by determinations of mass flow of combustion air and fuel. Since a wide range of compression ratios has been covered, it is important to be able to appraise relative performance and this has been done by reporting fuel and air consumptions in terms of a percentage of air-cycle efficiency, and this has been termed *relative* efficiency. Specific consumptions of fuel and air are, however, reported. Specific fuel and air consumptions are obtained under different conditions which, in each case, attempt to burn air or fuel as completely as possible and this is covered in detail in the text. Relative efficiency in terms of air is often neglected, but it may be pointed out that improving thermal efficiency in terms of air produces the same effect as increased volumetric efficiency. Improved thermal efficiency in terms of air may usually be expected to increase output without the increase of octane number that is usually required when volumetric efficiency is increased.

Knock-limited performance has been treated in terms of permissible combustion-chamber air den-

* Paper "Cylinder Performance—Compression Ratio and Mechanical Octane-Number Effects" was presented at SAE National Passenger-Car, Body and Production Meeting, Detroit, March 15, 1950. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

C.R. Engine Detonation Study

BASED ON PAPER* BY

S. D. Heron
Consulting Engineer

and

A. E. Felt
Research Engineer
ETHYL CORPORATION

sity on any given fuel. This density has been termed knock-limited true air density. Since mass airflow data are so rarely available an empirical equivalent of true air density was investigated and knock-limited density index was evolved. Density index is derived from imep, air-cycle efficiency (in per cent), and compression ratio as follows:

$$\text{Density index} = \frac{\text{Imep (compression ratio - 1)}}{\text{Air-cycle efficiency}}$$

That this piece of arithmetical mumbo-jumbo bears a reasonable relation to true air density is shown by Fig. 2. Most of the knock-limited data are reported in considerable detail in tables given in the full text of the paper, and this will enable those who don't like the authors' methods of analysis to make analyses which seem more appropriate.

Since data enabling true air density to be used are so rarely available, density index is used for most of the discussion. Density index and true air

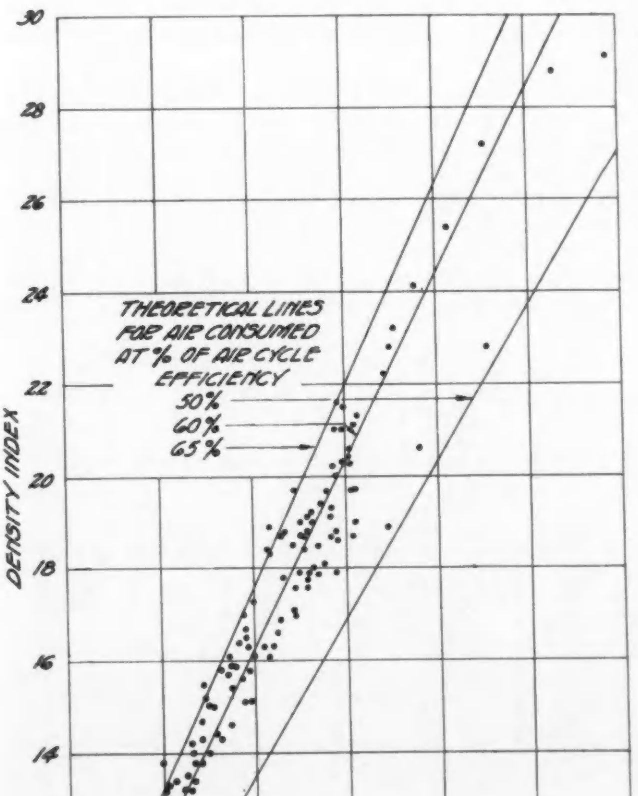


Fig. 2—Relation of knock-limited true air density to knock-limited density index

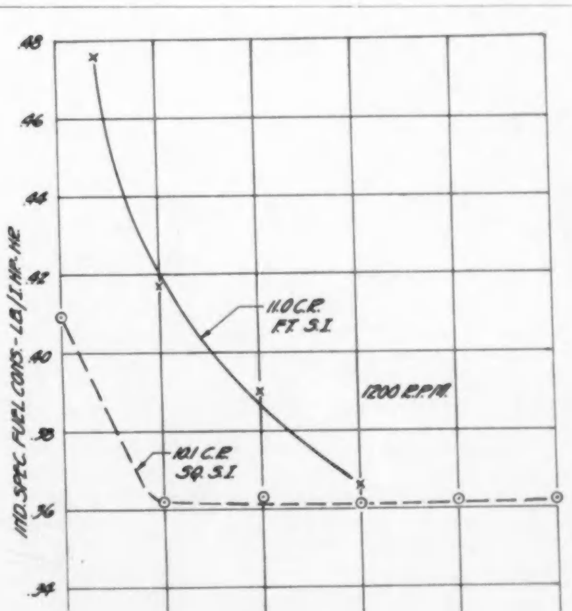


Fig. 3—Specific fuel consumption versus intake manifold pressure for two combustion chambers of 10.1 and 11.0 compression ratio. Maximum economy fuel/air ratio and spark advance

density take account of both compression ratio and volumetric efficiency, and this is obviously important since W. M. Holaday has shown that an automobile with about 7 to 1 compression ratio runs quite well on heptane if the throttle is not opened too much.

In order to be able to equate knock-limited performance at different octane-number levels, density index is divided by the AN performance number, multiplied by 100, and the result is termed figure of merit.

$$\text{Figure of merit} = \frac{\text{Density index} \times 100}{\text{Performance number}}$$

This procedure, of course, piles empiricism upon the empiricism of density index. A good engine may have a figure of merit of 30, whereas it can be as low as 8 when high temperatures of cylinder and mixture are used. Figure of merit at least tells whether the engine is good, bad, or indifferent. Determination of figure of merit is confined to cases where the knock-limited performance is determined in terms of primary reference fuels.

An important factor in the knocking behavior of a passenger-car engine is its performance on sensitive fuels and figure of merit is no guide in this respect. In this paper 80% diisobutylene + 20% heptane (hereafter 80% D.I.B.) has been almost entirely used as the sensitive test fuel and its knock-limited performance has been compared with that of isooctane and 80% octane + 20% heptane. The result is expressed as imep ratio and this is the ratio of the knock-limited imep of 80% D.I.B. divided by the knock-limited imep of isooctane or 80 octane number and enables the performance of the blend to be located in terms of the reference fuel blends. In addition to the use of 80% D.I.B., a considerable amount of testing was carried out with straight diisobutylene (hereafter 100% D.I.B.).

In the work reported, the procedure has been to vary manifold pressure to determine knock-limited performance on isooctane, 80 octane number, and 80% D.I.B. We have used this rather than running the engine at constant manifold pressure and determining the necessary blend of reference fuels that would just give incipient knock. The test program has been devoted to the determination of cylinder performance and not to testing fuels. The fuels tested were merely necessary tools for the determination of cylinder performance. Pure compounds have been used throughout as fuels and this has made it possible to compare data with those obtained in other laboratories with other engines.

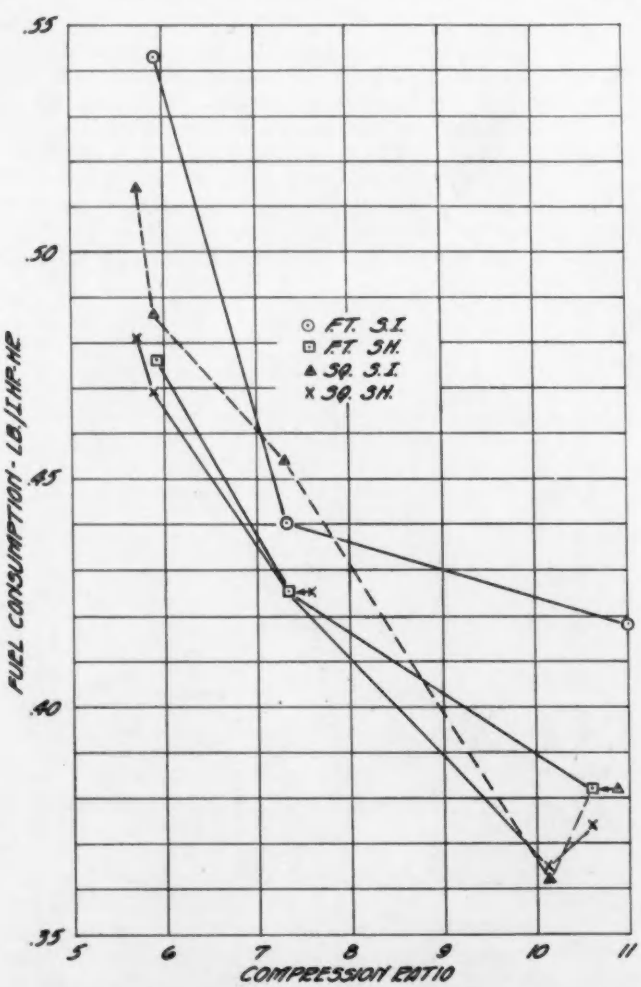


Fig. 4—Fuel consumption versus compression ratio and combustion-chamber type at 1200 rpm and 15 in. of Hg absolute manifold pressure with maximum economy fuel/air ratio and maximum economy spark advance

Test Data

Fuel economy has been considered to be an item of major interest in the test program and economy at the approximate speed and load corresponding to 30 mph road load in a passenger-car engine has been considered as the most important economy criterion. An engine speed of 1200 rpm and an intake manifold pressure of 15 in. of Hg absolute have been chosen as reasonably representative of 30-mph road load.

Fig. 3 shows the fuel economy of two combustion

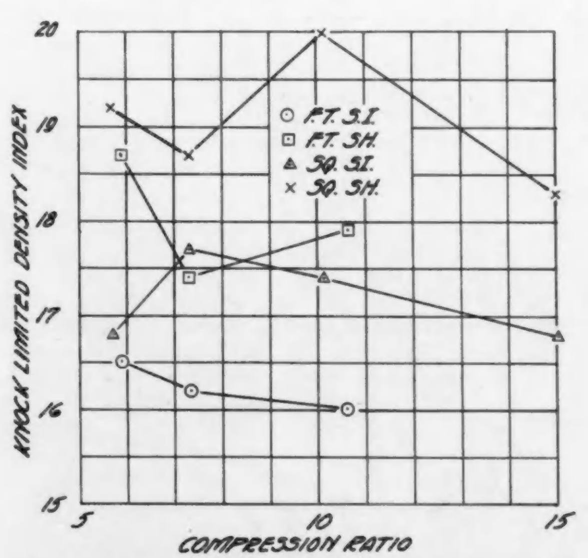


Fig. 5—Knock-limited density index of iso-octane at 1200 rpm versus compression ratio and combustion-chamber type

chambers of similar compression ratio over a range of manifold pressure and is sufficient to show that full-throttle economy is not necessarily any index of part-load economy.

Fig. 4 shows specific fuel consumption versus compression ratio at 1200 rpm and 15 in. of Hg manifold pressure for four groups of combustion chambers under maximum economy conditions. This figure further shows the pronounced effect of combustion-chamber design upon part-load fuel economy. The full text shows that the fuel economy is invariably considerably better at 3000 rpm than it is at 1200 rpm. The full text also shows that part of the gain in fuel economy with increase of compression ratio results from the fact that maximum fuel economy is developed at a leaner mixture as the compression ratio is increased. It is also shown that fuel air ratio is at least as important as compression ratio in respect to fuel economy. *Relative* thermal efficiency in terms of air has been determined for all cases where *relative* thermal efficiency in terms of fuel is reported. All thermal efficiency data were obtained in the absence of knock. *Relative* thermal efficiencies in terms of both fuel and air do not differ widely over a considerable range of compression ratio. In the light of the data presented *relative* thermal efficiency appears to be a reasonably sound method of reporting data obtained over a compression ratio range of 5.7 to 15.0.

The full text of the paper compares the *relative* thermal efficiency of the "27 cylinder" with that of overhead-value and L-head passenger-car engines and shows that a well-developed L-head engine has a thermal efficiency similar to that of a good overhead-valve type.

Knock-Limited Performance—Effects of compression ratio and combustion-chamber type: Fig. 5 shows the relation of knock-limited density index of isooctane at 1200 rpm versus compression ratio and combustion-chamber type. It is worthy of note that at the 10 to 1 compression ratio level the best combustion-chamber combination is about 25% better than the poorest type. Fig. 6 shows the effect of rpm and compression ratio on the knock-limited density index of isooctane for squish pistons. Fig. 7 shows the imep ratio of 80% D.I.B. versus compression ratio and rpm for squish pistons. This figure shows that both compression ratio and rpm are engine severity factors and these effects are shown for all combustion-chamber types.

Fig. 8 shows the effects of turbulence in terms of per cent gain in density index for the 7.3 compression group. This figure is somewhat complex and difficult to follow but shows the gain for each type of turbulence over a range of rpm and for both isooctane and 80% D.I.B. The base is the flat-top piston with standard intake valve and gains due to shroud, to squish, and to shroud and squish together can be seen. For each speed and for each

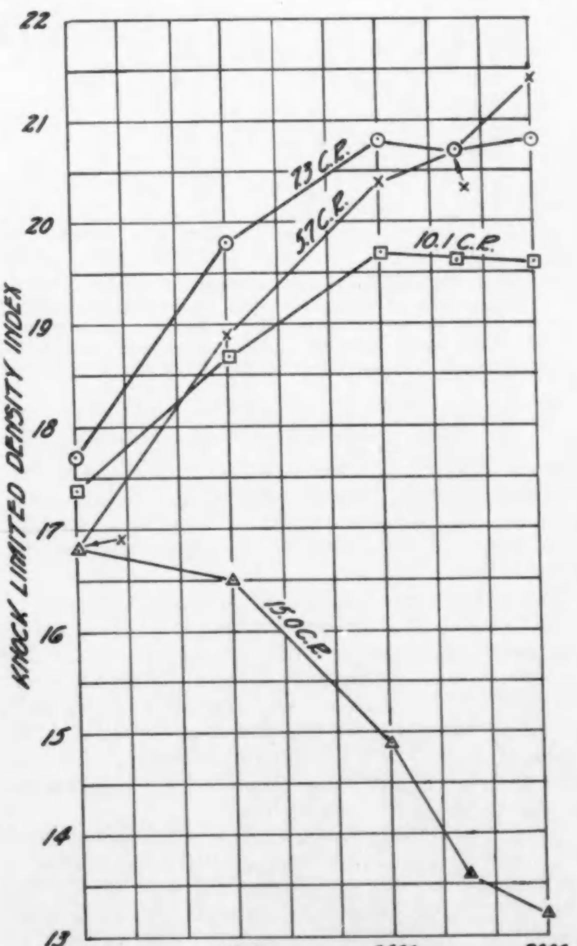


Fig. 6—Knock-limited density index of iso-octane with squish pistons and standard intake valve versus compression ratio and rpm

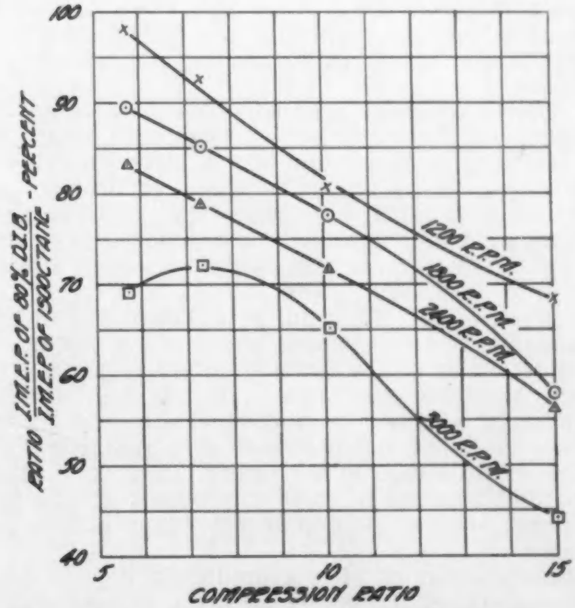


Fig. 7—Imep ratio of 80% D.I.B. versus compression ratio and rpm for squish pistons and standard intake valve

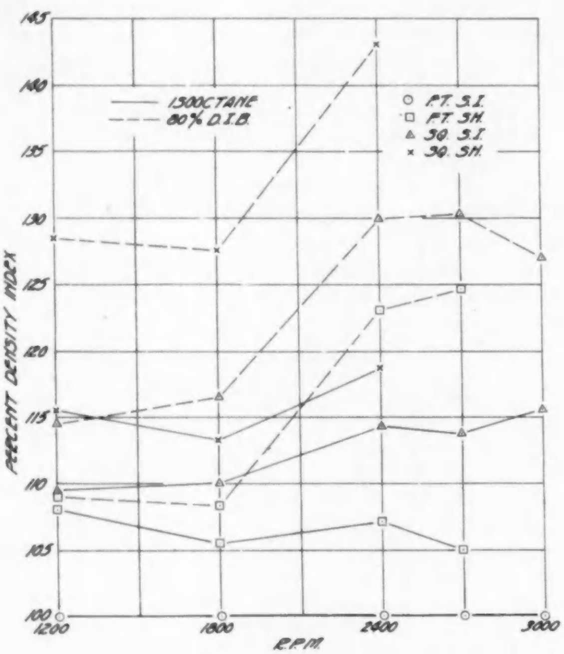


Fig. 8—Percent gain in density index due to turbulence versus rpm for iso-octane and 80% D.I.B. 7.3 compression ratio group

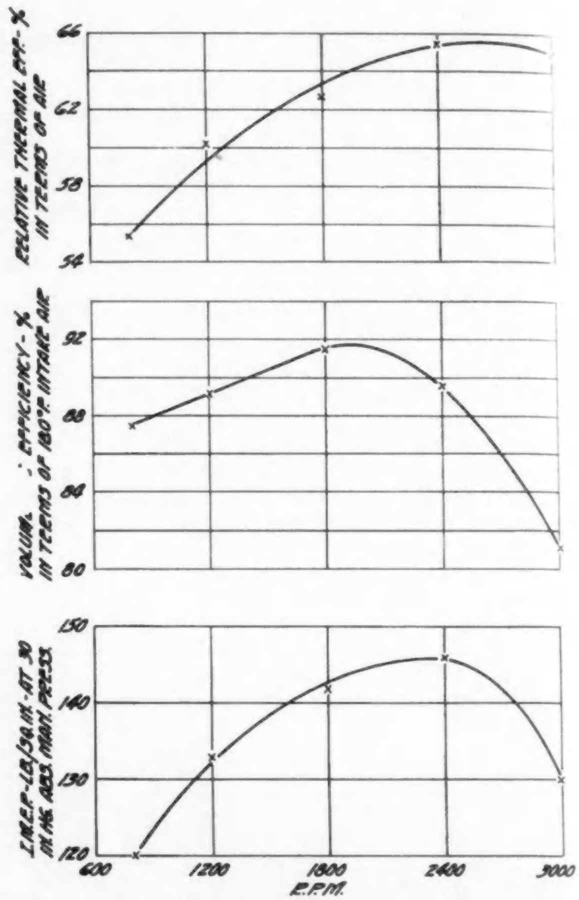


Fig. 9—Imep, volumetric efficiency, and relative thermal efficiency on air versus rpm. 10.1 compression ratio squish piston —standard intake valve—180 F jacket inlet temperature—180 F intake air temperature—0.080 fuel/air ratio—maximum power spark advance—30 in. of Hg absolute manifold pressure

fuel the value with the flat-top piston and standard intake valve is 100%. It will be noted that the gains for 80% D.I.B. are greater than they are for iso-octane.

Effects of cylinder temperature and intake air temperature: The data show that the cylinder is decidedly sensitive to the effects of temperature and particularly so in the case of the diisobutylene blends. The data show that increasing jacket water temperature at the cylinder base while maintaining it at a low temperature in the cylinder head has significant effects in increasing the tendency to knock.

Effects of spark advance: The data show that spark advance has very pronounced effects on knock. It is shown that the relative performance of diisobutylene blends in terms of primary reference fuels varies very widely with spark advance. Thus, an octane number of a diisobutylene blend is only significant for the particular spark advance used to obtain the rating.

Effects of fuel/air ratio: It is shown that fuel/air ratio has relatively slight effects upon the knocking tendency of the primary reference fuels. The very sensitive diisobutylene blends are, however, markedly affected by fuel/air ratio and an octane number of such blends must be qualified by the fuel/air ratio used in the rating. It is shown that, for sensitive fuels mixture enrichment offers a useful and practical method of reducing or eliminating knocking.

Combination of effects producing engine mildness: Detailed discussion in the complete text of the effects of the combination of reducing temperature of jacket water and intake air with a spark retard producing a 2% drop from maximum power shows that combination is extremely effective in respect to octane-number requirements and increases the density index of isooctane by 20-25% and that of 80% and 100% diisobutylene by 50-90%.

Miscellaneous knocking effects: Exhaust valve temperature is often considered to be a major cause of knocking in poppet valve engines. The "27 cylinder" is equipped with a sodium-cooled valve as standard. This valve was replaced with a solid valve of identical external dimensions. No difference in knock-limited density indexes of isooctane or 100% D.I.B. could be detected as a result of reduced exhaust valve cooling.

Tests were carried out at 30 to 1 compression ratio with a flat-top piston and a shrouded valve. At a manifold pressure of 7.2 in., heptane, 40 octane-60 heptane, isooctane, isooctane + 6 cc lead, triptane + 4 cc lead, and benzene all gave a sharp, clear knock and all except heptane gave a clean cut on the ignition switch. Reducing the manifold pressure by 1 in. gave a clean ignition cut with heptane. The piston was then modified to a squish type of 21.3 compression ratio. At 21.3 compression ratio the engine gave a density index of 15.2 for isooctane at

200 rpm and an index of 14.2 for 80 octane number. Thus, at 21.3 compression ratio there is almost no octane-number response between 80 and 100 octane number.

Effects of Compression Ratio on Volumetric Efficiency—It has frequently been stated that an increase of compression ratio reduces volumetric efficiency. No effects of compression ratio which are significantly outside the limits of experimental error in measuring volumetric efficiency have been detected in the "27 cylinder." Fig. 9 shows imep, volumetric efficiency, and *relative* thermal efficiency in terms of air versus rpm for the 10.1 compression ratio squish piston with standard intake valve. This figure shows that estimation of volumetric efficiency from imep is somewhat unreliable. It also shows poor *relative* thermal efficiency in terms of air at low rpm.

Discussion

Rothrock and coworkers at the NACA were, as far as the authors know, the first to introduce the concept of relating combustion-chamber air density to knocking. Evvard, Branstetter, Alquist and O'Dell of the NACA have shown that the limiting factor for isooctane is the combination of charge density and compression temperature and that as the temperature increases the knock-limited density decreases. They show that it does not matter whether the temperature results from compression ratio or from intake temperature.

The presently reported work is in conflict with the findings of Evvard et al, since it is shown that for isooctane at 1200 rpm and constant intake temperature, the knock-limited true air density is independent of compression ratio over a compression ratio range of 5.7 to 15.0 to 1. It has been computed that the compression temperature is nearly 600 F higher at 15 to 1 compression ratio than it is at 5.7. Possible reasons for the divergence in the findings of the "27 cylinder" and of Evvard et al are discussed in the full text of the paper. While the "27 cylinder" shows that the knock-limited true air density of isooctane at 1200 rpm is independent of compression temperature produced by compression ratio it also shows that an increase of compression temperature produced by increased intake temperature has a marked effect in reducing permissible density.

In conclusion, it may be remarked that the design of the "27 cylinder" attempted to take in too much territory in covering a compression ratio range of 5 to 30. The result is that the cylinder at any compression ratio is inferior to a cylinder designed specifically for that ratio.

Gasket Material Spec To Simplify Selection

Based on paper by

J. P. WILSON

Ford Motor Co.

A joint SAE-ASTM specification now under way sets up a significant numbering system for gasket materials. It will help designers pick the right material for the job by giving physical properties, according to the committee developing the specification.

Each material will carry a four-digit identification number, prefixed by the letter "G" —meaning gasket. The first digit denotes type. Type 1 is rubber and/or synthetic rubber composition; Type 2, cork compositions; Type 3, plant fibers; and Type 4, asbestos fibers. The second digit will indicate class, further describing the material's composition. The third digit will denote the group the material falls into, and the fourth, the particular item in that group.

Suffixes will be added for further refinement to indicate physical properties. This is necessary because the same material may be available in several different compressibility values, for example.

As an illustration of what the numbers mean, the designation G 1222-3 would represent the following material: rubber (Type 1); rubber-cork composition (Class 2); oil resistance (Group 2); a combination of high temperature and good oil resistance (represented by Item 2); and a compressibility of 30% (represented by suffix -3 in the physical property table).

It is planned to add new materials to the specification as they come into use even after its approval by SAE and ASTM. (Paper "Gaskets as Engineering Materials," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

AERO MEETING

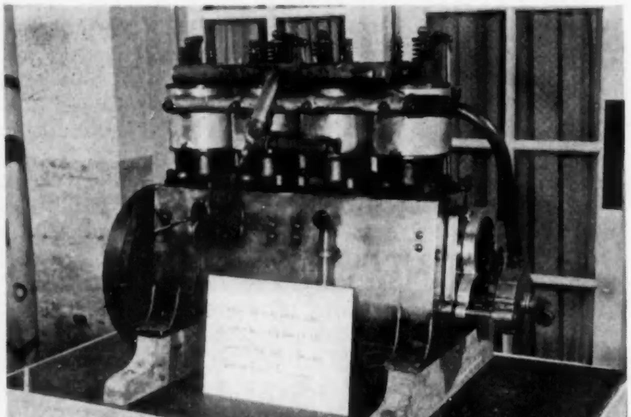
Turbojets

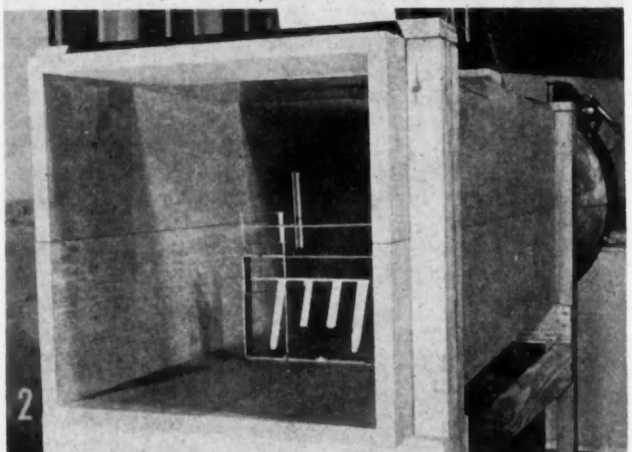
THE SAE National Aeronautic Meeting made it clear that there will be places for both turbojets and turboprops in air transport service after 1955 and maybe even before.

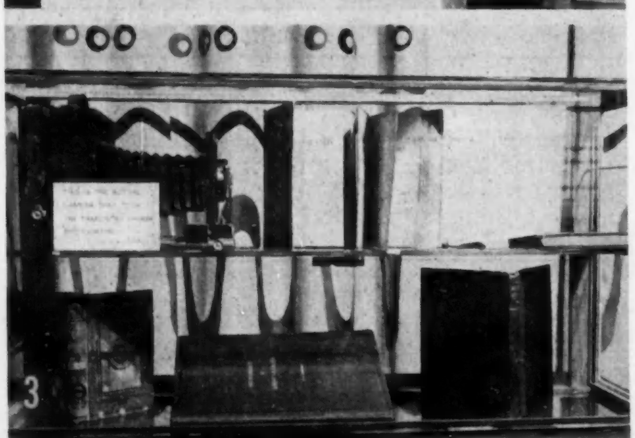
The meeting drew more than 700 engineers to New York's Hotel Statler to participate in three days of technical interchanges, to look over the largest aircraft engineering display SAE ever had, and to tour New York International (Idlewild) Airport. At the all-day panel on air transportation after 1955, there was literally standing room only. British and Canadian accents mingled at this and other sessions with accents from all parts of the United States. But as SAE President Zeder observed at the dinner, "Engineering is the language we all speak."

Major General Laurence S. Kuter, USAF, Commander, MATS, speaking at the dinner Wednesday evening on "The Transport Airplane as Related to Future Military Plans" concluded that:

"Economic factors indicate that there will be no substantial change in quantity of American airlift until there has been substantial improvement in quality. One method with promise of improving quantity is the design, development, large-scale manufacture, and use of truly low-cost cargo-carrying transport aircraft. . . . In this field I believe the







Feature of the meeting was an exhibit of Wright Brothers material, which was shown in conjunction with a paper entitled, "The Wright Brothers as Aeronautical Engineers," by M. P. Baker, Inland Mfg. Division, GMC. Highlights of this exhibit were:

1 Wright Brothers engine No. 56, which is exactly the same as the one used in the first airplane sold to the U. S. Army

2 Exact working replica of the wind tunnel used by the Wright Brothers in 1901

3 Camera used to take famous "Kitty Hawk" picture of first flight and some books used by the Wright Brothers in their research work

4 Picture of first flight and actual propeller from 1905 airplane

FORECASTS

and Turboprops After 1955

turboprop offers great promise. Several more years of experience and development of turbojet power for large aircraft are necessary before one could forecast when after 1955 that source of power can produce substantial increases of airlift that will be available to the military planner."

Avro's Jetliner was flown in just under 60 minutes from the Avro plant at Toronto to Idlewild so that participants in the meeting could see it on their tour. The seven busloads of visitors saw also military and experimental jet aircraft and turbojet, turboprop, and propeller displays.

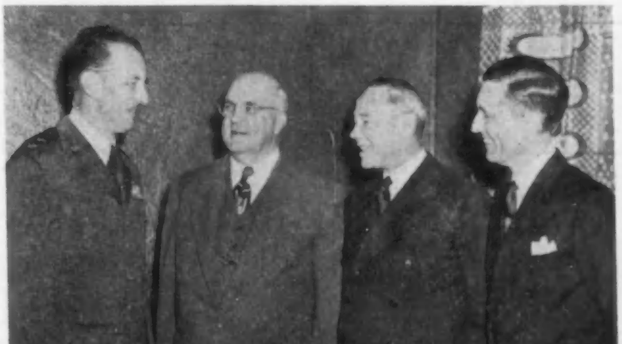
The meeting left this impression:

- The Canadians and British are ready to go into production on both turbojets and airframes for jet transports, and their airlines have already ordered small numbers. Chief objection to these units is high fuel consumption.
- American and British engine builders have several turboprops now flying experimentally and more on the way for commercial transport use. Many regard these turboprops as the next logical step in air transport engines because postwar transports now using piston engines can be converted for turboprops. Besides, these turboprops offer considerably better fuel economy than presently available turbojets.
- Both turboprop and turbojet designs will benefit over the next few years from such developments as inlet anti-icing, more efficient compressor types, higher pressure ratios, and higher gas temperatures. Variable-area jet nozzles will increase propulsive efficiency of turbojets, and better propellers will do the same for turboprops.
- Ultimately, turbojets will power transports for 600 mph and maybe faster flights over major routes. Turboprops will power transports for 400-500 mph shorter-haul flights.

Turbojets will have other commercial uses. Their freedom from vibration and their high speed will be a boon to aerial photography, and together with improved photographic techniques, will increase its use.

SAE is contributing to this progress in propulsion through its aeronautical standardization committees, which were termed an important element in the success of current industry-services cooperative standardization.

At the Dinner . . . .



Left to right: Major-Gen. Laurence S. Kuter, commander of Military Air Transport Service, USAF, was chief speaker at the Aeronautic Meeting dinner. SAE President James C. Zeder, spoke briefly; Adm. DeWitt C. Ramsey, president of the Aircraft Industries Association, was toastmaster; and Richard Creter, chairman of SAE Metropolitan Section welcomed the dinner guests to New York

Turbine Transportation Previewed

No one ventured to name the day when passengers will be flying regularly in the 600-mph turbojet transports. But it was shown that the day of 400-mph jet transports may not be far off. The Canadian Avro Jetliner and the British deHavilland Comet are already flying. Both use centrifugal-compressor turbojets designed initially for military use where high power was more important than fuel economy, it was recalled.

The British are also readying the Rolls-Royce Dart turboprop for actual cargo service over BEA routes in Viscounts in 1952, although the Dart has

SAE Vice-Presidents

W. A. PARKINS
Aircraft Powerplant Activity

H. D. HOEKSTRA
(left)
Aircraft Activity

R. D. KELLY
(right)
Air Transport Activity

Wright Brothers Medal recipients H. J. Wood (center) and F. Dallenbach (left), AiResearch Mfg. Corp., receiving the medals and certificates from John G. Lee (right), United Aircraft Corp. and chairman of the Board of Award.

Messrs. Wood and Dallenbach received the award for their paper, "Auxiliary Gas Turbines for Pneumatic Power in Aircraft Applications."

no military background. In this country, Allison will soon have T-38 turboprops flying in a Convair 240 to work out the bugs and develop operating techniques for cargo and passenger transport. Allison also disclosed plans to fly the T-40 turboprop in cargo aircraft within the next year. First flight of a T-40 in a Convair XP5Y flying boat was made the day of the panel discussion and announced there.

The Dart, having a centrifugal compressor and therefore no surge problem, will have simpler control, it was explained. Counter attractions of the Allison turboprops' axial compressors are more favorable specific weight and fuel consumption. (It was generally agreed that centrifugal compressors cost less to build and are more robust but that they will gradually be abandoned in favor of axial compressors, which are more efficient and offer opportunities for much higher pressure ratios.)

The U. S. airlines engineers present showed interest in all these developments. They seemed inclined to delay buying turbine-powered equipment until fuel economy is improved and other flaws corrected. But they indicated that if one American airline took the lead in buying and flying turbine-powered equipment, the sales value of its novelty—especially if it was jet equipment—might force all competitors to follow suit in turbines.

Operators were told that if they do buy the early turbine-powered aircraft, they need not fear overwhelming maintenance costs. Initial overhaul periods are likely to be 500 hr. Cost of overhauls will be about the same as it has been for piston engines. (Rolls-Royce is willing to overhaul the Dart five times for a price equal to the initial price of the engine.) There will be need for little repair or replacement between overhauls, it is expected.

Engine repair experts figure that the most likely sources of trouble with turbine engines are (1) the

Exhibitors in Aircraft Engineering Display

Airborne Accessories Corp.	Kollsman Instrument Division, Square D Co.
Aircraft-Marine Products, Inc.	Lear, Inc.
Barber-Colman Co.	McGraw-Hill Book Co., Inc.
Bendix Products Division, Bendix Aviation Corp.	Metals & Controls Corp.
Boeing Airplane Co.	Micro Switch
Chase Aircraft Co., Inc.	Minneapolis-Honeywell Regulator Co.
Cleveland Pneumatic Tool Co.	Parker Appliance Co.
Curtiss-Wright Corp.	Ryan Aeronautical Co.
Elastic Stop Nut Corp. of America	Scintilla Magneto Division, Bendix Aviation Corp.
A. H. Emery Co.	Scott Aviation Corp.
Fafnir Bearing Co.	Shell Oil Co.
General Controls Co.	Stratos Corp.
General Laboratory Associates, Inc.	Titeflex, Inc.
Heli-Coil Corp.	Vickers, Inc.
Hydro-Aire, Inc.	Westinghouse Air Brake Co.
Jack & Heintz Precision Industries, Inc.	

hot areas of burners and first turbine stages, (2) bearings, and (3) controls.

Some operating problems were foreseen. One military operator warned that turbojets installed on the horizontal centerline of airplanes tend to burn runway blacktop if they habitually idle at one spot. He suggested that it might be possible to arrange to retract the nosewheel slightly, thus deflecting the jet upward. He added that Navy handlers are instructed that the more powerful the jet engine, the longer is the danger zone behind the jet nozzle during ground operation. British engineers present reported that the Comet's nozzles are 6 ft above the ground and therefore above the heads of most personnel. They also reported that lower jet streams will usually knock a man to the ground and below stream range before he has time to be badly burned.

Operators heard that clearing runways of snow with jets is out of the question because of the fuel required. Besides, jets tend to blow the snow away rather than to melt it.

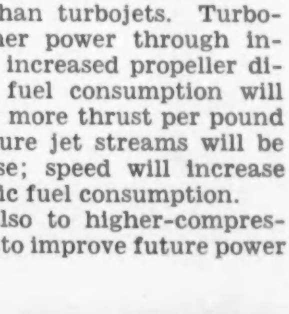
Portable screens were recommended as a means of keeping personnel out of the dangerous intake area. (Engines with axial compressors are more likely to suck in a person than those with centrifugal compressors, discussion disclosed.)

Noise, it developed, will be one of the big problems for jet operators. Everyone agreed that jets are noisy. No one knew what to do about it.

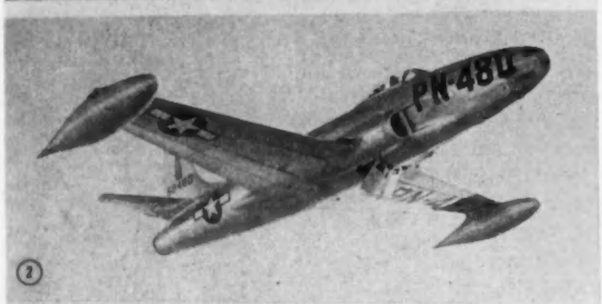
While operators seek solutions to maintenance and operational problems of turbine-powered aircraft, engine builders hope to improve the breed by decreasing fuel consumption, improving reliability, and increasing power. One of their first goals will be to permit higher burner-outlet temperatures. This may be done by going to ceramic-lined annular burners and to ceramic turbine blades that can stand higher gas temperatures or hollow internally cooled blades, either of which blade types will keep down blade temperatures while gas temperatures go up.

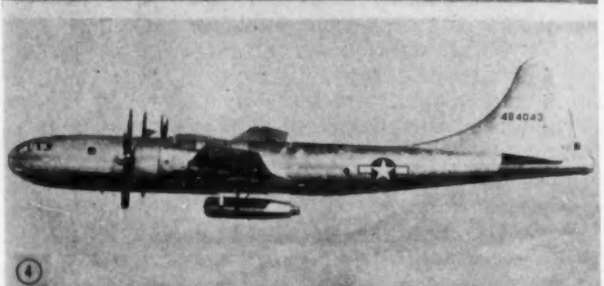
Turboprops are likely to benefit more from increased gas temperatures than turbojets. Turboprops will absorb the higher power through increased power coefficient or increased propeller diameter, and their specific fuel consumption will drop. Turbojets will deliver more thrust per pound of gas but higher-temperature jet streams will be less efficient propulsion-wise; speed will increase with thrust but so will specific fuel consumption.

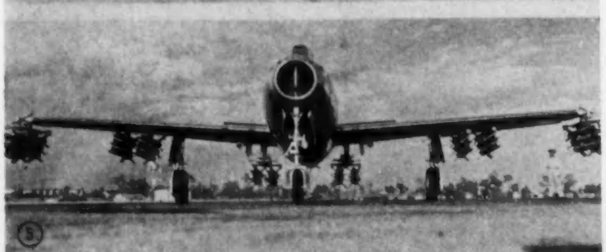
Engine builders looked also to higher-compression-ratio, dual compressors to improve future power



E. C. Sulzman, (above), general chairman of the Aeronautic Meeting, and Charles Froesch, general chairman, all-day panel discussion on "Air Transportation After 1955—Whooosh! ! !"







Inspected by SAE At Idlewild

1 Air Force North American B45 Tornado 4-jet bomber. One of America's first operational bombers to employ jet propulsion

2 Air Force Lockheed F80 Shooting Star jet fighter. This plane completed first west-east crossing of Atlantic by jet aircraft

3 Navy Grumman F9F Panther fighter. Navy's newest carrier-based, 600-mph jet fighter

4 Air Force "Flying Laboratory." A B29 with General Electric J47 turbojet engine slung from fuselage to enable flight research at high altitudes and under icing conditions

5 Air Force Republic F84 Thunderjet fighter has radius of better than 850 miles and service ceiling above 45,000 ft

6 Air Force North American F86 Saber jet fighter holds world's speed record of 671 mph with its combat load of guns and ammunition

7 A. V. Roe C102 Jetliner was demonstrated at Idlewild for SAE members. This was first time Jetliner had been to United States

8 Allison T40 turboprop engine develops 5500 hp and weighs 2500 lb

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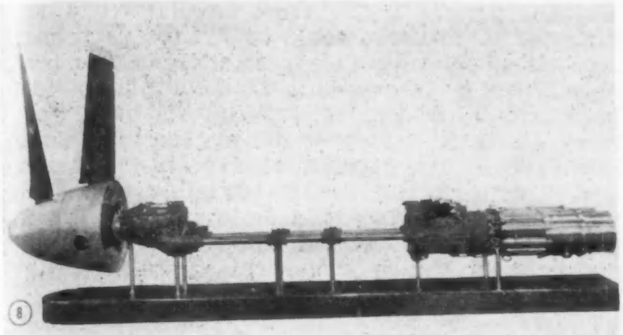
and fuel economy. Turbojets will probably acquire variable-area nozzles, which can contribute considerably to fuel economy but make powerplant control much more complex. Both the dual compressors and the variable-area nozzles will add to the specific weight of turbojets, making thrust augmentation for take-off a likelihood.

If this augmentation takes the form of afterburning, the variable nozzle and its controls will be subjected to white-hot-gas temperatures instead of mere red-hot gases. This is expected to add to control and maintenance problems. Control of a turbojet with variable-area nozzles and afterburning was said to be just about as complicated as control of a turboprop.

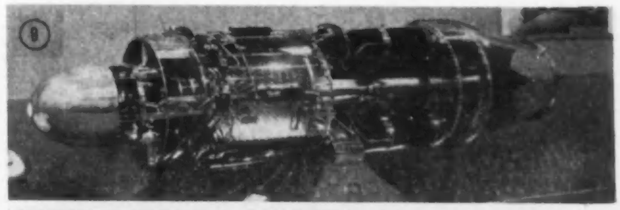
Engineers agreed that sometime after 1955 when both turbojets and turboprops are well developed, turbojets will take the very high-speed jobs and

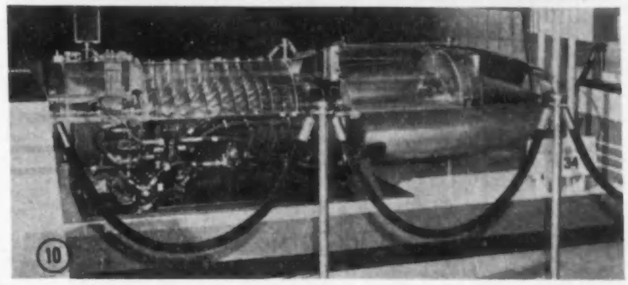


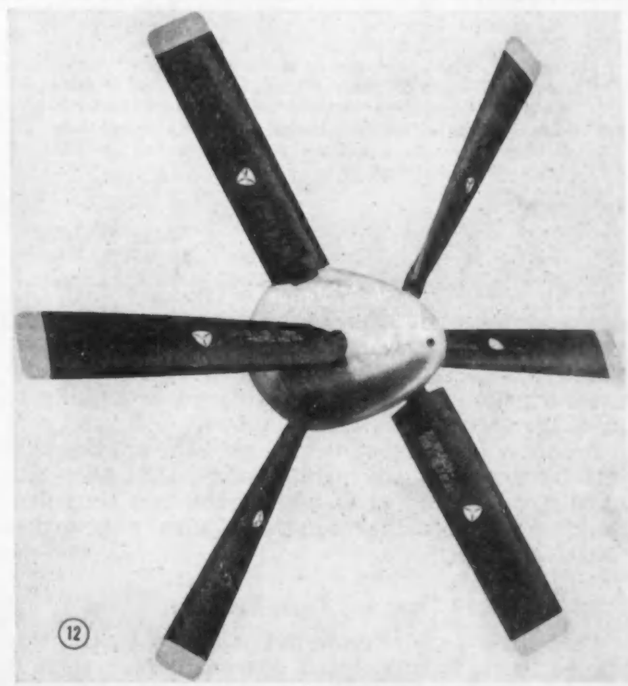
Members Airport

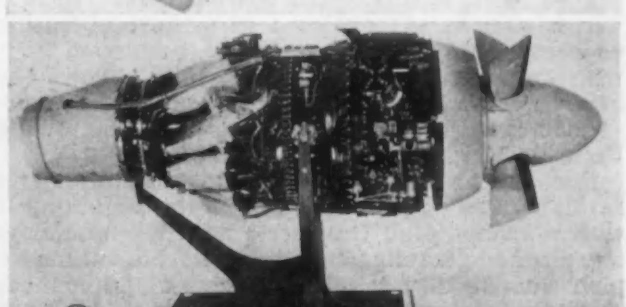
R. D. SPEAS

Chairman, Idlewild Inspection Trip









9 General Electric J47 turbojet engine has take-off thrust of over 5200 lb, weighs 2500 lb. It was first axial-flow type to be certificated by CAA for commercial use

10 Westinghouse J34 turbojet engine. Compressor is of axial-flow type, with 11 stages. Turbine is of 2-stage axial-flow type. Engine weighs 1200 lb

11 Armstrong-Siddeley Mamba turboprop engine has 2-stage centrifugal compressor, 2-stage turbine. Four of these engines are fitted to Vickers-Armstrong Viscount airliner

12 Aeroproducts propeller for Allison T40 turboprop engine. Propeller is for use with turbine engines of 5000-10,000 hp

13 Rolls-Royce Dart turboprop engine has 2-stage contrifugal compressor, which feeds seven combustion chambers, and 2-stage axial turbine

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turboprops the lower-speed jobs.

But they foresaw then as at present a border zone of speeds where the turboprop and turbojet will be almost evenly matched. Right now, the speeds between 400 and 500 mph seem to represent the border zone. (The division depends partly on the state of propeller development.) In this zone, choice between turbojets and turboprops will be based on considerations such as ultimate safety and passenger appeal.

Proponents of turboprops consider that propellers give turboprops a safety advantage over turbojets in the braking available in propeller pitch reversing, particularly for landing braking. These people found support, too, in a report on in-flight reversing of all four propellers on a C-54 (powered by reciprocating engines, of course). Rates of descent up to 11,000 fpm were attained at an indi-

Based on discussions and 17 papers presented at eight sessions under the chairmanships of **R. P. Kroon, R. E. Minton, Hugh Dryden, J. B. Franklin, W. W. Davies, P. B. Taylor, D. R. Shoults,** and **J. D. Clark.** Papers "Turbojet Engines—Service Experience," **J. W. Bailey,** Allison Division, General Motors Corp. . . . "The Extended Service Life of Propeller Turbine Engines," **R. N. Dorey,** Rolls-Royce, Ltd. . . . "A Review of a Year's Operation of the Curtiss-Wright Dehmel Flight Simulator," **Scott Flower,** Pan American Airways, Inc. . . . "Investigation of Reversing Propeller Pitch on a Multi-Engine Aircraft In Flight," **H. O. Fisher,** Propeller Division, Curtiss-Wright Corp. . . . "The Wright Brothers as Aeronautical Engineers," **M. P. Baker,** Inland Manufacturing Division, General Motors Corp. . . . "Passenger Markets for Future Airplanes," **H. E. Nourse,** United Air Lines, Inc. . . . "Air Speed Doesn't Mean a Thing," **R. L. Turner.** . . . "Airlines Scheduling and Flight Equipment Routing After 1955," **M. E. Warshaw,** Trans World Airlines. . . . "Ground Operational Problems with Jet-Powered Aircraft," **E. C. Taylor,** American Airlines, Inc.—Questioner; **R. E. Small,** General Electric Co.—Answerer . . . "The Impact of Jets on Air Traffic Control," **S. P. Saint,** Air Transport Association of America . . . "Jet Powerplant Maintenance and Overhaul," **John Borger,** Pan American Airways, Inc.—Questioner; **R. B. Rogers,** Westinghouse Electric Corp. —Answerer . . . "The Case for the Turbojet," **Winnett Boyd,** A. V. Roe Canada, Ltd. . . . "The Case for the Turboprop Engine," **R. M. Hazen,** Allison Division, General Motors Corp. . . . "Stereoscopic Aerial Photography—Present Applications and Future Possibilities," **Col. G. W. Goddard,** USAF, Air Materiel Command . . . "Design Problems of Large Aerial Cameras," **D. E. MacDonald,** Boston University . . . "Military Aeronautical Standardization," **R. C. Rethmel,** Air Materiel Command . . . "Is Teamwork the Answer in Aeronautical Standardization?," **J. H. Sidebottom,** Aircraft Industries Association, and **G. N. Cole,** Pratt and Whitney Aircraft, Division of United Aircraft Corp. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.**

cated air speed of 200 mph. Turboprop enthusiasts reasoned that aircraft could fly at the high altitudes which favor turbines without fear of depressurization if they could descend as rapidly as in-flight propeller reversing allows.

Proponents of turbojets advanced the opinion that jets have caught the public fancy, that they will have stronger appeal to passengers, and that passengers may consider anything with a propeller "old fashioned."

3 Transport Types Foreseen

The first turbine-powered transports, it was agreed, will be introduced for extra-fare service. These aircraft are expected to achieve operating economies and attract more traffic, both from Pullman travelers and by self-generation. Then the airlines will add to their turbine equipment. Conversion of major routes to jets was predicted to take three to five years.

The key to making the eventual 600-mph and faster equipment profitable may lie in combining it with medium-speed transports and helicopters, as one airline scheduling expert saw it. He outlined a plan whereby fastest jet transports would connect "primary" airports located near major cities—none of which would be more than four hours apart by jet transports. Traffic from smaller cities with "secondary" airports would be fed to the primary airports by 400-mph, 40-passenger transports, probably driven by turboprops. Traffic would be fed to both primary and secondary airports by 120-mph block speed, 20-passenger helicopters from downtown areas. The medium transports would serve also on short hauls in the 150-500 mile range. Block speed is only one factor in destination-to-destination speed, it was pointed out, and on a 500-mile flight the advantage of an airplane cruising at 600 mph over one cruising at 400 mph is negligible.

"Micro hauls" of less than 150 miles would use the helicopter.

This would cut down on costly jet landings and take-offs, insure the jets profitable load factors by increasing their drawing area, minimize costs of airports and maintenance facilities, and offer passengers the most attractive schedules, it was claimed.

Jet aircraft and propeller-driven aircraft can use the same air traffic control system—if future air traffic control systems are designed properly, engineers were assured. Jets need better, but not fundamentally different, control. Efficient use of the airways may require segregation of aircraft according to speed category and to communication, navigation, and traffic control equipment carried. But they can use the same terminals.

Of course, jet aircraft will not be maneuvered under engine power in congested ramp areas. They will be towed at least a short distance from the loading platform. Whether they are towed all the way to the end of the runway will depend largely on how much fuel can be sacrificed to this operation.

Hope of reducing costs of training flight crews to fly the proposed new aircraft and use the new traffic control systems came in a report on Pan-American Airways' success with the Dehmel Flight Simulator in training Stratocruiser crews. They figure that on a fleet of 20 Stratocruisers, this training device could save an airline over $100,000 per year on recurring training alone. They see no reason why the simulator could not offer similar savings on other types of aircraft.

Not all the new transports will be flying passengers and cargo, if two aerial photography experts have their way. They described new steroscopic techniques which they feel can serve in determining lumber content of forests, estimating crops, obtaining flood control data, surveying, and military intelligence. The less the vibration and the higher the speed, the greater the accuracy of the photography, they said, in explanation of why photographers prefer turbine-powered aircraft.

Commercial and military users of aircraft and their suppliers have begun intense cooperative standardization through such agencies as SAE committees, the AIA, and the Research and Development Board of the National Military Establishment, it was reported. They hope to stabilize policies, organizations, and personnel. Both military and civilian standards experts stressed the importance of basing standards on usage, rather than risking setting a standard impossible to meet. But they want their standards kept abreast of design developments, which the meeting indicated are sure to come.

CALENDAR

Atlanta Group—May 15

Town House Tea Room; dinner 6:30 p.m. Meeting 8:00 p.m. Cooling System Problems—Robert James Foley, automotive specialist (service engineer), National Carbon Co., Inc., and Elmer Edward Sanborn, mechanical engineer, National Carbon Co., Inc. Social hour.

Baltimore—May 11

Engineers Club of Baltimore; dinner 7:00 p.m. Meeting 8:00 p.m. Heavy Duty Fleet Maintenance — Louis A. Bode, superintendent, automotive shops, Baltimore Transit Co.

Buffalo—May 25

Park Lane Restaurant; dinner 6:30 p.m. Meeting 8:00 p.m. Statistical Quality Control—Edward Young, Jr., chief enspector, Ford Motor Co., Buffalo Plant. Moving picture—Human Bridge.

Central Illinois—May 15

Jefferson Hotel; dinner 6:30 p.m. Meeting 7:45 p.m. The Influence of Accessory Equipment on Design of Modern Track Type Tractors—J. Milton Davies, director of research, Caterpillar Tractor Co.

Chicago—May 23

Knickerbocker Hotel; dinner 6:45 p.m. Meeting 8:00 p.m. Subject to be announced. Speaker: Walter E. Shively, manager, Tire Design Development Department, Goodyear Tire and Rubber Co. Social half hour sponsored by Goodyear Tire and Rubber Co. and Voltz Bros.

Cleveland—May 8

Automatic Transmissions — Joseph Geschelin, Detroit editor, Automotive Industries. Samples of transmissions, now or soon to be in production, will be available for inspection. Automobiles equipped with the various transmissions will be available for test driving.

Detroit—May 23

Book-Cadillac Hotel. Problems in the Application of Atomic Energy—Dr. Lawrence Hafstad (director, Reactor Development Division, Atomic Energy Commission. Toastmaster: Walter L. Cisler, executive vice-president, Detroit Edison Co.

Indiana—May 23

Antlers Hotel; dinner 7:00 p.m. Meeting 8:00 p.m. Cummins High Speed Diesel Engine—Application to 500 Mile Race—J. C. Miller, Jr., manager, research and refinement, Cummins Engine Co., Inc. Social hour sponsored by S. A. Silbermann, Metallurgical Service Co., Inc.

Northern California—May 15

Engineers Club, San Francisco, Calif.; dinner 6:30 p.m. Meeting 7:30 p.m. The Morris Diamond Diesel Engine—Donald W. Morris, Morris Development Co. Prepared discussion of paper to be presented.

Oregon—May 12

Corvallis, Ore. Dinner 6:00 p.m. Silencing System—L. H. Billey, engineer, Donaldson Co., Inc.

Philadelphia—May 12

Bala Country Club; dinner 7:00 p.m. Reception and entertainment for members, wives and guests.

Pittsburgh—May 23

Oil City, Pa. Dinner 6:30 p.m. Meeting 8:00 p.m. 150 mpg Is Possible—R. J. Greenshields, director research, Shell Oil Co., Inc.

Southern New England—May 12

Wethersfield Country Club; dinner 7:00 p.m. Spring Outing — Ladies Night. Golf, prizes, dancing, and dinner.

Saint Louis—May 9

Bill Medart's; dinner 7:00 p.m. Meeting 8:00 p.m. Presentation of student papers by Parks College Student Chapter and introduction of newly-elected Section Officers. Social half hour before dinner. Cocktails—Courtesy of Reid Auto Parts.

Washington—May 16

Burlington Hotel; dinner 6:30 p.m. Meeting 8:00 p.m. Torque Converters —Past and Future—A. H. Deimel, chief engineer, Hydraulic Transmission Division, Spicer Division, Dana Corp. Lantern slides.

NATIONAL MEETINGS

SUMMER	June 4-9	French Lick Springs, French Lick, Ind.
WEST COAST	August 14-16	Biltmore Los Angeles, Calif.
TRACTOR	Sept. 12-14	Schroeder Milwaukee, Wis.
AERONAUTIC and Aircraft Engineering Display	Sept. 27-30	Biltmore Los Angeles, Calif.
TRANSPORTATION	Oct. 16-18	Statler, New York
DIESEL ENGINE	Nov. 2-3	Knickerbocker Chicago, Ill.
FUELS and LUBRICANTS	Nov. 9-10	Mayo Tulsa, Oklahoma
ANNUAL MEETING and Engineering Display	1951 Jan. 8-12	Book-Cadillac, Detroit

SAE Summer

June 4-9, 1950

SUNDAY, June 4

8:30 p.m.

Feature Motion Picture

MONDAY, June 5

9:30 a.m.

L. L. WITHROW, Chairman

Precombustion Reactions in a Motored Engine
—D. L. PASTELL, E. I. du Pont de Nemours & Co.

The Elimination of Combustion Knock —Texaco Combustion Process
—E. M. BARBER, BLAKE REYNOLDS, and W. T. TIERNEY, The Texas Co.

(Sponsored by Fuels and Lubricants Activity)

ROUND TABLES

2:00 p.m. to 4:00 p.m.

SUBJECT and SPONSORING ACTIVITY	LEADER
Service Operational Difficulties with the Aircraft Engine Exhaust Valve and Seat Insert (Aircraft Powerplant)	R. W. YOUNG
Wear of Piston Rings, Cylinders, Camshafts, and Tappets (Engineering Materials)	C. G. A. ROSEN, Caterpillar Tractor Co.

8:30 p.m.

F. C. MOCK, Chairman

Recent Developments in the R-4360 Engine
—E. A. RYDER, Pratt and Whitney Aircraft Division, United Aircraft Corp.

(Sponsored by Aircraft Powerplant Activity)

TUESDAY, June 6

9:30 a.m.

J. W. PENNINGTON, Chairman

Valve Problems in Diesel Engines
—VINCENT AYRES, Eaton Manufacturing Co.

Prepared Discussion

(Sponsored by Diesel Engine Activity)

2:00 p.m.

ROBERT CASS, Chairman

Symposium on Engine Wear

E. J. GAY, Technical Consultant, J. B. DUCKWORTH, Standard Oil Co. (Indiana), and R. E. JEFFREY, Shell Oil Co.
Effects of Sulfur in Motor Gasoline on Engine Operation (Report of Coordinating Research Council on the Investigation of Sulfur in Motor Gasoline)

W. S. JAMES and B. G. BROWN, Fram Corp.
Engine Wear as Affected by Air and Oil Filters

T. B. RENDEL, Shell Oil Co.
Surgery versus Medication

H. G. BRAENDEL, Wilkening Manufacturing Co.
Design Features Affecting Wear

J. S. VANICK, International Nickel Co.
Corrosion versus Engine Wear

(Sponsored by Fuels and Lubricants Activity)

ROUND TABLES

2:00 p.m. to 4:00 p.m.

SUBJECT and SPONSORING ACTIVITY	LEADER
Multi-Purpose Passenger Vehicle Bodies (Body)	F. S. SPRING, Hudson Motor Car Co.
Lubricating Oil Filters and Filtration Problems in Diesel Engines (Diesel Engine)	H. V. NUTT, U. S. Naval Engineering Experiment Station
Fatigue and Service Testing of Automotive Parts (Engineering Materials)	A. F. UNDERWOOD, Research Laboratories Div., General Motors Corp.
Noise and Vibration Problems (Passenger Car)	L. M. BALL, Chrysler Corp.
Cooling System Problems	J. R. HOLMES, Harrison Radia-

Meeting

French Lick Springs Hotel

French Lick, Indiana

(Passenger Car)	tor Division, General Motors Corp.

8:30 p.m.

E. H. KELLEY, Chairman

Automatic Transmissions—Today—Tomorrow
—A. H. DEIMEL, Spicer Manufacturing Division, Dana Corp.
The Ford-Mercury Automatic Transmission
—H. T. YOUNGREN and H. G. ENGLISH, Ford Motor Co.
(Sponsored by Passenger Car Activity)

WEDNESDAY, June 7

9:30 a.m.

L. RAY BUCKENDALE, Chairman

Operational Stresses in Automotive Gears
—EARLE BUCKINGHAM, Massachusetts Institute of Technology
Economics of Automotive Gear Steels and Their Heat Treatment
—V. E. HENSE, H. H. MILLER, and R. B. SCHENCK, Buick Motor Division, General Motors Corp.
(Sponsored by Engineering Materials Activity)

2:30 p.m. **Field Day**

8:30 p.m.
General Session

J. C. ZEDER, Chairman

Our Future Around the World
HENRY J. TAYLOR
Author, Economist, and Journalist

THURSDAY, June 8

9:30 a.m.

M. E. NUTTILA, Chairman

Tires and Tubes for Commercial Vehicles and Some Factors Affecting Their Service
—G. M. SPROWLS, Goodyear Tire and Rubber Co.
(Sponsored by Transportation and Maintenance Activity)

ROUND TABLES

2:00 p.m. to 4:00 p.m.

SUBJECT and SPONSORING ACTIVITY	LEADER
Current Automotive Seating Problems and Designs (Body)	J. D. CATON, Chrysler Corp.
Automotive Suspensions (Passenger Car)	W. E. BURNETT, Ford Motor Co.
Do We Need Higher Voltages for Automobile Electrical Systems? (Passenger Car)	H. L. HARTZELL, Delco-Remy Division, General Motors Corp.
Where Does Leasing of Vehicles Fit into the Long-Range Transportation Problem? (Transportation and Maintenance)	H. L. WILLETT, Jr., Willett Co.
Brake Testing and Procedures for Determining Performance and Wear, Including What Constitutes a Safe Stop (Truck and Bus)	P.T.BRANTINGHAM, International Harvester Co.

7:30 p.m.

Presentation of SAE CHAMPIONSHIP GOLF CUP

8:30 p.m.

R. A. TERRY, Chairman

Development of Modern Upholstery Fabrics
—W. F. BIRD and C. L. CONLEY, Collins and Aikman Corp.
Display of Modern Transportation Upholstery Fabrics
(Sponsored by Body Activity)

FRIDAY, June 9

9:30 a.m.

F. B. LAUTZENHISER, Chairman

The Gasoline Consumption and Travel Time of Motor Trucks
—C. C. SAAL, Bureau of Public Roads
(Sponsored by Truck and Bus Activity)

ROGER M. KYES has been appointed general manager of the GMC Truck & Coach Division of General Motors Corp., Pontiac, Mich. He joined General Motors in August, 1948, as director of its central office Procurement and Schedules Staff. In October of that year he was appointed assistant general manager of the GMC Truck & Coach Division.

JAMES T. GREENLEE, formerly sales manager, has been appointed vice-president and director of Imperial Brass Mfg. Co., Chicago. In his new position he is in charge of all of the company's industrial sales in the automobile, truck, tractor and refrigeration fields. Greenlee joined the company in 1910.

GEORGE H. FREERS has been promoted by the directors of Marmon-Herrington Co., Inc., Indianapolis, Ind., to vice-president in charge of engineering. For the past ten years he has held the position of chief engineer.

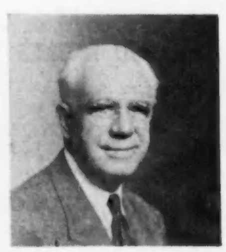
A. F. FENNER, vice-president of Mack International Motor Truck Corp., has been named general sales manager, with headquarters in Chicago. He will direct all of the company's truck, bus and fire apparatus sales and service activities in its Central, Southwestern and Pacific Coast Divisions, as well as the Republic of Mexico.

RICK FREUND, formerly sales manager for Thompson Products, Inc., at the West Coast Plant, Bell, Calif., has gone into engineering sales and service for several suppliers of engine parts, from Cleveland headquarters.

WILLIAM A. FURST has joined O. E. Szekely and Associates, Philadelphia, Pa., as chief engineer. He was formerly plant superintendent with the Atlas Imperial Diesel Engine Co., Oakland, Calif.

POSTLETHWAITE

TIMMERMAN



WATERS

P. B. POSTLETHWAITE, retired as president of Wagner Electric Corp., St. Louis, Mo., has been elected to the newly-created office of chairman of the board. He will continue also as chairman of the executive committee. **A. H. TIMMERMAN,** who joined Wagner in 1899, has retired as vice-president and director. Timmerman will be succeeded as a director by **G. A. WATERS**, vice-president in charge of manufacturing.

About

WILLIAM B. McFERRIN, formerly assistant manager of development in the Electro Metallurgical Division of Union Carbide and Carbon Corp., Detroit, is now executive vice-president of the corporation's Haynes Stellite Division at Kokomo, Ind.

CEDRIC H. FOSTER is general manager of Acme Bearings & Parts, Ltd., Toronto, Ont., Canada. He was formerly managing director of Petroleum Solvents Corp., Montreal.

GLEN EASTBURN, formerly manager of the Aviation Department, Los Angeles Chamber of Commerce, has resigned to accept a position as executive secretary of the California Property Owners' Association.

REAGAN C. STUNKEL, has joined Hydro-Aire, Inc., Los Angeles, as vice-president and general manager. He was formerly president of Aviation Maintenance Corp. Stunkel is chairman of the SAE Southern California Section.

EDWARD D. KEMBLE, formerly plant manager of the Battle Creek Plant of Clark Equipment Co., is now with the Air Conditioning Department of General Electric Co., Bloomfield, N. J.

WILLIAM L. BATT, president of SKF Industries, Inc., Philadelphia, Pa., has recently been elected a director of American Standards Association. He took a leading part in the standardization campaign that united the United States, Great Britain, and Canada on the dimensions of screw threads.

NORMAN G. EDER has recently joined the Eureka Williams Corp., Bloomington, Ill., as a project engineer. He was formerly company engineer for Everybody's Oil Corp., Anderson, Ind.

RICHARD L. ZENKER is now a design and development engineer with Ranco, Inc., Columbus, Ohio. He was formerly research engineer with Battelle Memorial Institute, same city.

E. M. LUNDA is now assistant director of service, Mack Mfg. Co., Plainfield, N. J.

S·A·E Members

CHARLES F. KETTERING, director, General Motors Corp., was made an honorary member of the Engineering Society of Cincinnati on April 20. On that same day he spoke before that Society on "Future Developments in High Compression Engines and Fuels."

JAMES POSAVAC is now product and development engineer with the Brabant Brass Mfg. Co., Detroit. He was formerly co-owner of the Illinois Butane Gas and Equipment Co., Inc., Bloomington, Ill.

R. M. WELKER has been named chief fuels and lubricants engineer, Passenger Car Section, Automotive Products Engineering, for Gulf Oil Corp., Pittsburgh, Pa. He was formerly with the Lubricating Sales Department of Gulf, where he has since served in various capacities.

HENRY W. LUETKEMEYER has recently been elected vice-president-engineering of the Cleveland Graphite Bronze Co. He joined the company in 1933 as a production worker, and has been chief engineer since 1946.

KENNETH L. MILES, formerly assistant chief engineer with the Hydra-Line Division of Johnston Enterprises, Los Angeles, is now administrative engineer in the NEPA Division of Fairchild Engine and Airplane Corp., Oak Ridge, Tenn.

A. C. HARTMAN, formerly project engineer for Wright Aeronautical Corp., Wood-Ridge, N. J., is now a staff engineer in the Aircraft Products Division of Air Associates, Inc., Teterboro, N. J.

RAYMOND G. BENNETT is now associated in a sales capacity with the B. G. Corp., New York City, manufacturers of aviation, industrial and automotive sparkplugs. He was formerly with the California Texas Oil Co., Ltd., same city, as an automotive engineer.

A. A. BRADD is supervisor of heat treatment for the Philadelphia Gear Works, Inc., Philadelphia, Pa. He was formerly superintendent of heat treatment and assistant superintendent of research for the Midvale Co., same city.

ROBERT H. DAISLEY has recently been made a director of the Cleveland Graphite Bronze Co. He is vice-president and director of manufacturing of Eaton Mfg. Co.

JOHN L. COLLYER, president of the B. F. Goodrich Co., received the honorary degree of Doctor of Commercial Science from the New York University School of Commerce, Accounts and Finance on April 11. Other SAE members who were honored were **ALFRED P. SLOAN, JR.**, chairman of the board, General Motors Corp., and **PAUL G. HOFFMAN**, administrator, Economic Cooperation Administration.

CHARLES L. SEELBACH, formerly supervisor of the Products Section, Lubricants Department, Shell Oil Co., New York City, is now assistant manager of the Lubricants Department of Shell at Cleveland, Ohio.

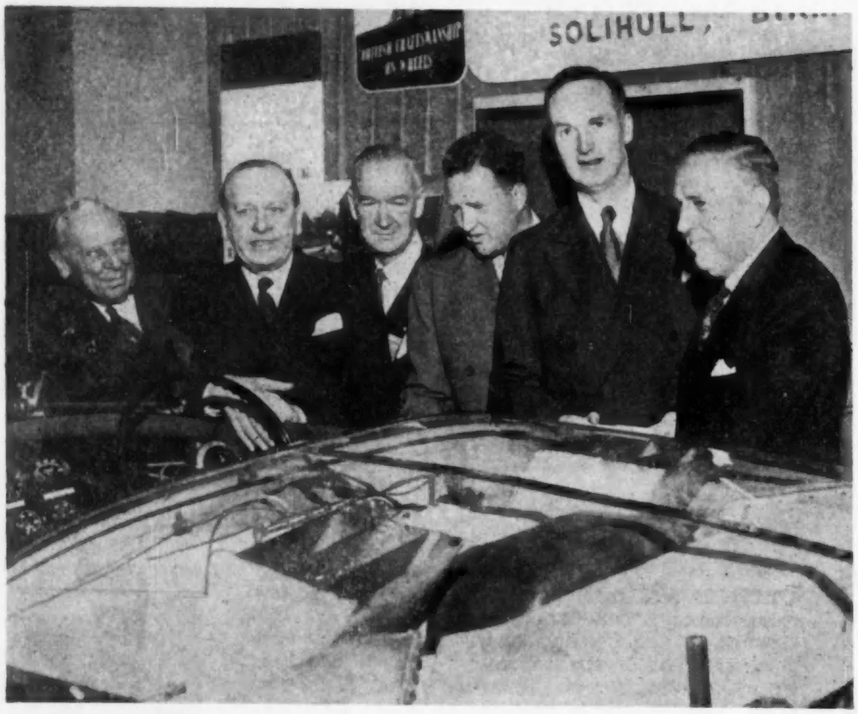
GORDON W. MacKINNEY is now assistant general sales manager with the Propeller Division of Curtiss-Wright Corp., Caldwell, N. J. He was formerly assistant to the sales manager there.

GEORGE W. KEOWN has been appointed general sales manager of Tung-Sol Lamp Works, Inc., Newark, N. J., it was announced by **R. E. CARLSON**, vice-president of the company. Keown has been with Tung-Sol for six years as initial equipment sales manager and is well-known in the lamp and electron tube industries.

HEMAN H. ALLEN, assistant chief, Section of Safety, Bureau of Motor Carriers, Interstate Commerce Commission, retired on Feb. 28 after more than 30 years of service with the Federal Government. His time was equally divided between service in the Commission and the National Bureau of Standards, where he was engaged in automotive research. Allen plans to travel in France, England and Scotland, and upon his return he will take up his avocation—the study of pipe organ tone—possibly to build a pipe organ.

P. W. LITCHFIELD (left), board chairman of the Goodyear Tire and Rubber Co., is shown receiving the Insignia of the Royal Order of Vasa, first class, from G. Oldenburg, Consul General of Sweden. The honor was conferred on the Akron industrialist recently by King Gustav of Sweden for helping to build good business relations between the United States and Sweden. Litchfield will complete a half century with the Goodyear company this June.

SAE Members at British Car Show Opening



PAUL G. HOFFMAN (right), administrator, Economic Cooperation Administration and former Studebaker Corp. president, opened the British Automobile and Motor Cycle Show in New York last month. Inspecting the Rover gas turbine-powered car with him are (right to left): Sir Oliver Franks, British Ambassador to the United States; **HENRY FORD, II**, president, Ford Motor Co.; **G. H. SAVAGE**, works director, Rover Co., Ltd.; **SIR WILLIAM ROOTES**, chairman, Rootes, Ltd.; and **ALFRED P. SLOAN, JR.**, chairman of the board, General Motors Corp.

WALTER S. DACK has recently resigned as engine design engineer for White Motor Co., Cleveland, Ohio. He is now responsible for sales and service of fuel injection equipment for diesel engines in North America, for C. A. V., Ltd., London, England. Dack will direct his activities from offices in Cleveland.

WILLIAM F. LITTLE, engineer in charge, Photometric Department, Electrical Testing Laboratories, Inc., New York City, has been named by the Illuminating Engineering Society to receive its 1950 Gold Medal at ceremonies during the National Technical Conference at Pasadena, Calif., in August. The Gold Medal, highest honor in the field of illumination, is awarded "for meritorious achievement conspicuously furthering the profession, art or knowledge of illuminating engineering."

RONALD B. SMITH, who joined the M. W. Kellogg Co., New York City, in 1948 as director of engineering, has recently been named a vice-president of the company. He is a consultant to the Atomic Energy Commission and a member of the National Advisory Committee for Aeronautics.

PHILIP D. BOEHM, JR., is now a manufacturers agent, representing a group of automotive manufacturers in the sale of their products in Alabama, Georgia, and Florida. His company name is Philip D. Boehm Co., Atlanta, Ga. He was formerly a salesman for Lawrence M. Herzig Co., Jacksonville, Fla.

F. M. AULD, formerly sales representative, is now fleet and commercial manager, Mercury-Lincoln-Meteor Division, Ford Motor Co. of Canada, Ltd., Winnipeg, Man., Canada.

JOHN B. HANSON has recently joined Federal Supply Service, U. S. Government, Washington, D. C., as a purchasing agent. He was formerly equipment superintendent for the Corps of Engineers, Seattle, Wash.

JOHN FORBES is now a sales engineer for J. A. Tumbler Laboratories, Ltd., Toronto, Ont., Canada. He formerly held a similar position with Radiator Specialities of Canada, Ltd., same city.

CHARLES LIPSON, consultant, Detroit, G. C. Noll, and L. S. Clock have just published a book entitled "Stress and Strength of Manufactured Parts." It is published by McGraw-Hill, New York, for $4.50.

JOHN HENRY GLASS is manager, Pressed Metal, Chevrolet-Flint Mfg., Flint, Mich.

ROBERT J. WRIGHT, formerly a field engineer with Wright Aeronautical Corp., Wood-Ridge, N. J., is now sales engineer on gas turbines and air starters for AiResearch Mfg. Co., Los Angeles, Calif.

HUDSON T. MORTON is president of Morton Bearing Co., Ann Arbor, Mich. The company has recently purchased the machinery and assets of the New Britain Bearing Co., Inc.

ROBERT H. THORNER, who is a consulting engineer in Detroit, is temporarily connected with Pierce Governor Co., Anderson, Ind.

JOSEPH M. SILLS is now executive vice-president of Tropic-Aire, Inc., Chicago, Ill. He was formerly assistant general manager of maintenance with the Greyhound Corp., same city.

JOHN C. MORTON has recently joined the Barnes Drill Co., Rockford, Ill., as a tool engineer.

ROBERT C. MILLER is now a supervisory production trainee with the Ohio Boxboard Co., Rittman, Ohio.

HERBERT KLEPPER, who graduated last January from Rensselaer Polytechnic Institute, Troy, N. Y., is now an engineering trainee in the Research & Development Department of Merganthaler Linotype Co., Brooklyn, N. Y.

E. T. VINCENT, professor of mechanical engineering at the University of Michigan, has just had a new textbook, "The Theory and Design of Gas Turbines and Jet Engines," published by the McGraw-Hill Book Co. Chapters on theory alternate with chapters on application of the theory to specific design problems. Relative pressure and enthalpy of air for the temperature range 380-2500 R are given in nomograph form on a large sheet carried on a pocket of the book's back cover. Price of the volume is $7.50.

ROBERT A. MONTGOMERY, formerly automotive engineer, Department of the Army, Washington, D. C., is now chief, Specifications and Procurement Unit, U. S. Army, Department of Defense, Office of the Chief of Ordnance, Washington, D. C.

ROLLAND D. KOENITZER, formerly assistant chief engineer for Brown Fintube Co., Elyria, Ohio, is now owner of R. D. Koenitzer, Oberlin, Ohio, manufacturers of metal sealing rings for pipe flanges.

C. M. FLUKE, formerly assistant regional coach manager, West Coast, White Motor Co., San Francisco, is now transportation engineer for White at Boston, Mass.

JOHN GELB, formerly a design engineer with the Harley Davidson Motor Co., Milwaukee, Wis., is now senior mechanical engineer with Verson Allsteel Press Co., Chicago, Ill.

WILLIAM BERLINER is now a test engineer for General Electric Co., Bloomfield, N. J. He formerly held a similar position with the company's Aircraft Gas Turbine Division at Lockland, Ohio.

FOSTER R. GAYLORD, formerly president of Columbia Truck Leasing, Inc., Kansas City, Mo., is now vice-president of Columbia Terminals Co., St. Louis, Mo. Succeeding Gaylord as president of Columbia Truck Leasing is **E. L. BAILEY**, who had been safety director and manager of the Leased Department.

EDWIN C. MAKI, formerly a designer with Ford Motor Co., Dearborn, Mich., is now in the Advanced Engineering Department of International Harvester Co., Ft. Wayne Works, Ft. Wayne, Ind.

J. C. WIDMAN is a body engineer in the Ford Division of Ford Motor Co., Dearborn, Mich.

G. M. BUEHRIG, is supervisor of the Body Development Studio, Ford Motor Co., Dearborn, Mich.

HOWARD W. FRANK, formerly chief engineer for Fiveboro Equipment Co., Flushing, N. Y., is now sales director for product design at Martial & Scull, New York City.

SAE members were prominent this year at the annual dinner held for the pacemaker of the Indianapolis race. Among them were **BENSON FORD**, general manager, Lincoln-Mercury Division, Ford Motor Co. (right) and SAE Past-President **A. W. HERRINGTON**, board chairman of Marmon-Herrington Co. and chairman of the AAA Contest Board (left). The Mercury will be the pacemaking car for the 1950 race.

ROBERT B. LANE, formerly project engineer with Rohr Aircraft Corp., Chula Vista, Calif., is now resident engineer for Rohr at Convair, Fort Worth, Texas.

CHARLES C. SONS, JR., has recently joined Cummins Diesel Sales of Minnesota, Hibbing, Minn., as a field engineer. He was formerly a field research engineer for Cummins Engine Co., Inc., Columbus, Ind.

LOUIS P. CROSET has recently joined W. C. Holmes & Co., Ltd., Huddersfield, England. He was formerly with the Diesel Engine Division of Davey, Raxman & Co., Ltd., Colchester, England.

HERBERT L. BOARDMAN has joined the Webster Chicago Corp., Chicago, as a tool and machine designer. He was formerly associated with Barnes & Reinecke, Inc., same city.

EUGENE I. DEAS is now associated with the Vick Chemical Co., Philadelphia, Pa., as an engineering trainee. He is a recent graduate of the University of Virginia.

ARTHUR B. CASTO, who recently graduated from Indiana Technical College, Ft. Wayne, has joined the West Virginia State Road Commission as a draftsman in the Plans and Surveys Department at Charleston, W. Va.

JOHN G. HOLMSTROM (right), vice-president and general manager of Kenworth Motor Truck Corp., is examining the new 200-lb, 175 hp Boeing gas turbine engine which has been installed experimentally in one of his 10-ton Kenworth trucks. Preliminary road tests have just been finished. Stacks on either side of the driver's cab of the truck handle exhaust gases from the engine, which are approximately the same temperature as those from conventional engines.

RICHARD LANIER HUNT, a recent graduate of Cornell University, Ithaca, N. Y., has joined the Truck Division Of International Harvester Co., Buffalo, N. Y.

CALVIN LAWRENCE FICKETT is a draftsman with the Glenn L. Martin Co., Baltimore, Md.

R. T. PRATER has recently joined the Loeffler Greene Supply Co., Oklahoma City, Okla., as an engineer.

ROBERT G. GREENAWALT is a junior engineer in the Diesel Experimental Department of Fairbanks, Morse & Co., Beloit, Wis.

LEWIS K. GARIS, JR., who graduated last November from Indiana Technical College, Fort Wayne, has recently joined the Lincoln-Mercury Division of Ford Motor Co., Detroit, as a statistician in the Pre-production Planning Unit.

HARRY GUTTMAN, formerly a draftsman and junior engineer for American Car & Foundry Co., Berwick, Pa., is now senior draftsman with the Symington Gould Corp., Depew, N. Y.

J. A. McCOY is now with the Diesel Engine Development Division of Fairbanks, Morse & Co., Beloit, Wis. He was formerly a designer with Lavers Engineering Co., Chicago.

LEONARD E. HANNO, a recent graduate of the University of Illinois, is now a junior engineer in the Chemical Division of Corn Products Refining Co., Argo, Ill.

CHARLES E. ROGAN, JR., has recenly joined the Carbide & Carbon Chemicals Division of the Union Carbide and Carbon Corp., at South Charleston, W. Va.

JOHN FAEHNRICH is an installer with the Crafts Combination Window Co., Painesville, Ohio. He was formerly an electrician for Brown Pacific-Maxon Construction Co., San Francisco, Calif.

EDWARD STAWSKI is a calculator for the DeLaval Steam Turbine Co., Trenton, N. J.

CHRIS C. BURRY is a junior project engineer in the New Idea Division of Avco Mfg. Corp., Coldwater, Ohio.

JEROME V. KLAZURA is a mechanical-draftsman with the Rock Island Arsenal, Rock Island, Ill.

WARREN K. LIND has recently joined International Business Machines Corp., Endicott, N. Y., as an engineer trainee.

JOHN P. BRERETON, formerly an engineer with Eaton Metal Products Co., Denver, Colo., is now production engineer with Gasair Corp., San Francisco, Calif.

ARTHUR B. MacTAGGART, JR., formerly research engineer with Tillotson Carburetor Co., Toledo, Ohio, is now an engineer with Champion Spark Plug Co., same city.

WALTER B. MILLS is now a technical writer for Ford Motor Co., Center Line, Mich. He was formerly test engineer with Continental Aviation & Engineering Corp., Detroit.

B. B. NYE has recently joined Lear, Inc., Grand Rapids, Mich., as sales engineer. He was formerly co-partner of Tupelo Machine Works, Tupelo, Miss.

W. ERIC WILSON is a special tester at General Motors Corp., Products Study 4, Detroit.

GEORGE R. HELWEGE, formerly engineering aide with the U. S. Naval Engineering Experiment Station, Annapolis, Md., is now president and owner of George's Home Maintenance Co., Floral Park, N. Y.

ROBERT E. BUSBY, is a salesman with Ruckstell California Sales Co., Oakland, Calif. He was formerly sales manager and part-owner of Busby Bros., same city.

WILMER A. SPITZER is a graduate trainee for sales engineering at Caterpillar Tractor Co., Peoria, Ill.

HOWARD J. HUTSELL, a recent graduate of Indiana Technical College, Fort Wayne, is now refrigeration instructor at Universal Trade School, Inc., Omaha, Neb.

PAUL S. ROGERS has joined the graduate training program at Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. He graduated from the University of Oklahoma last January.

WM. R. BUTLER is manager of jobbing sales for Aluminum Co. of America, Pittsburgh, Pa.

ROBERT O. DERRICK, JR., a recent graduate of Yale University, is an engine test mechanic in the Electro-Motive Division of General Motors Corp. at LaGrange, Ill. In June he will start with the training program for graduates there.

WALTER M. IWANOWSKI is an aeronautical engineer in the Bendix Products Division of Bendix Aviation Corp., South Bend, Ind.

ROBERT O. GREEN, JR., has recently joined the Taylor Corp., Los Angeles, Calif., as a salesman.

JAMES E. BUBB is now a test engineer with the Lycoming Division of Avco Mfg. Corp., Williamsport, Pa.

J. W. SULLIVAN is a sales engineer with the Chicago Branch Office of The W. S. Tyler Co.

NORBERT V. RADTKE is a junior mechanical project engineer at E. I. Dupont de Nemours & Co., Inc., Seaford, Del.

VICTOR V. SNIDER, formerly assistant foreman, is now foreman with the P. R. Mallory Co., Inc., Indianapolis, Ind.

RALPH L. BUSSE, formerly vice-president of Timken-Detroit Axle Co., Detroit, retired from his position last January.

LEONARD H. MILLER has joined the Arkell Safety Bag Co., Newport News, Va., as assistant mechanical engineer.

C. F. VAN CULIN is associated with Van Culin Motors, Inc., Pleasant Beach, N. J. He was formerly connected with Ralph N. Brodie Co., Inc., New York City.

D. B. COLYER, JR., is an engineer in the Technical Development Division of United Air Lines, Inc., Denver, Colo.

Page Size of SAE Handbook . . . .

THREE QUESTIONS about SAE HANDBOOK page size are being asked by SAE Technical Board of members of SAE technical committees:

1. The Handbook will be most useful to me if the printed page size, 5½″ × 8″ is retained .... ☐
2. The Handbook would be more useful to me if the page size were increased to 8½″ × 11″ .... ☐
3. The Handbook would be equally useful to me with the present page size or with an 8½″ × 11″ size.... ☐

Responses from Society members in general and technical committeemen in particular will aid the Technical Board in reaching a decision as to the page size for future SAE Handbooks.

If YOU have opinions on these questions which you want considered, please write at once to Don Blanchard, secretary, SAE Technical Board, 29 West 39 St., New York 18, N. Y.

SAE Section Meetings

Engine Needs Dictate New H-D Oil Concepts

• Hawaii Section
Rene Guillou, Field Editor

March 6 — That the demands of modern, high-duty engines are leading to a new conception of heavy-duty oils, was emphasized by **Sol Onorato,** past-chairman of Northern California Section and automotive engineer with the Union Oil Co.

Wear factor, expressed in thousandths of an inch per thousand hours of service, is the primary criterion of oil performance, according to Onorato. Refined petroleum oil may be considered as a base, making only a minor contribution to the characteristics of a heavy duty oil and suffering little change in service. Viscosity index, detergency, oxidation inhibition, corrosion inhibition, and polar affinity were named as essential characteristics contributed by additives. Each of the additives used has a time and temperature life, and heavy duty oils deteriorate due to loss of additive effects or to contamination. Apparent thinning of oils from fuel dilution was mentioned as an example, the petroleum base itself actually thickening with use.

Turning to mechanical problems associated with high-duty engine service, Onorato favored the use of oil filters, preferably of the full flow type, but never with Fuller's earth elements, which absorb certain additives.

Valve maintenance was reported to be an increasing problem. Wide seats, close guide clearances, and delivery of cooling water initially to the head were mentioned as means of reducing high and damaging exhaust valve temperatures. These measures may also reduce octane requirement by several points. Onorato emphasized his belief that engines should be designed to operate efficiently on fuel of moderate octane rating, the cost of producing higher octane fuels being likely to defeat the first aim of efficiency, which is economy.

Low Cost Offsets Turbine Fuel Needs

• British Columbia Section
John B. Tompkins, Field Editor

Nov. 21—Boeing's new experimental all-gas turbine, weighing only 150 lb yet developing more than 200 hp, was revealed to SAE members at this meeting.

Joining in a little "star gazing," Speaker **S. D. Hage** could see no use for the gas turbine in present design automobiles in the "near future."

But he did predict a use in buses and trucks, of present design, as a "booster powerplant for short periods." Basic difference between the gas turbine and conventional reciprocating engine is the rotating function of the former's part as compared with the up and down motion of the reciprocating motor, the Chief of Boeing's Propulsion Development Division reminded his audience. Using slides, Hage illustrated his address with pictorial evidence of the turbine's low weight and high power output, its rapid temperature rise from 60 F at the air intake to 1500 F and down to 1100 F at the jets.

Offsetting the turbine disadvantage of high fuel consumption, Hage looked for ultimate low maintenance cost and low first cost, if and when mass production arrives, to popularize his motor. In five to 10 years, he predicted, it will provide "good competition" with gasoline and diesel powerplants. During experiments, engineers under Hage's direction have used as fuel "everything from kerosene to fuel oil with very little difference." And his engine, he claimed, "had good possibilities to burn fuel oil of a less-refined nature at a third to half cheaper" than ordinary motor fuels.

Concluding his address, Hage saw little possibility of the gas turbine as the primary powerplant in buses and trucks "until engineers realize the advantages of light weight motor and vehicle design."

Three Papers at Feb. Meeting

• Central Illinois Section
Ivan Lamport, Field Editor

Feb. 27—Sugar cane land in Hawaii is nearly as valuable as a strip of New York's Fifth Ave., Central Illinois Section members learned during discussion of three interesting papers which made up this second member-meeting of the year. **Jay Johnson**, Caterpillar sales engineer, recently returned from studying Hawaiian sugar production at close range, talked on "Mechanization of the Sugar Industry in Hawaii." **Dan K. Heiple**, chief engineer, R. G. LeTourneau, Inc., spoke on "Estimating Earthmoving Equipment Performance," and

President Zeder In Canada

SAE President James C. Zeder, chairman, Engineering Board, Chrysler Corp., spoke to the Canadian Section on March 15. Five of the seven seated with him at the speakers table were past-chairmen of Canadian Section. Left to right are: E. F. Armstrong, General Motors of Canada; J. L. Stewart, Canadian Automobile Chamber of Commerce; Warren Hastings, Canadian Motorist; President Zeder; Section Chairman W. W. Taylor, Prest-O-Lite of Canada; Hollister Moore, SAE Headquarters; Marcus L. Brown, Seiberling of Canada; and W. L. McGraw, Chrysler Corp. of Canada

Memo to Enrolled Students . . . .

The SAE Council has provided two options which enable graduates to continue affiliation with the Society when Student Enrollment expires on September 30th.

1. You may make application for regular membership before the expiration date and, if elected, you will be entitled to have your initiation fee waived. The waiver will save you one-half of what you would normally have to pay.
2. Graduates may apply for the $5.00 post-collegiate year which will allow you to participate in Society activity for your first year of employment at a reduced cost. You will continue to get a subscription to the SAE Journal. At the end of the post-collegiate year, which for this year's graduates would be September 30, 1951, you may still make application for regular membership and, if elected, have your initiation fee waived.

The second option is recommended for graduates, as it enables them to continue their affiliation with SAE at a low cost during their first year of employment and to determine better the value of SAE regular membership as related to their own jobs.

P.S. All graduating enrolled students will be contacted concerning these options before their enrolled student membership expires.

Ray F. Kern, chief metallurgist of Allis-Chalmers' Springfield Works, talked about "Economic Aspects of Gear Heat-treatment and Dimensional Quality Control."

Assessed valuation in Hawaii, Johnson said, is around $5,000 per acre. Heiple defined a 100-lb road as "a soil condition that produces a rolling resistance of 100 lb per ton of gross load." Kern, asked his opinion of flame hardening, said that, in his experience, it is too hard to control and, therefore, too expensive except under ideal conditions.

Body Engineers Have Broad Field

• Detroit Section

Ruth DeWald, Ass't Field Editor

Feb. 27—Over 700 engineers heard **J. J. Cronin,** vice president and general manager of the Fisher Body Division of the General Motors Corporation, say that he considered design of the automobile body equal in importance to design of the chassis. He went on to show that the body engineer faces many of the same problems as the chassis engineer together with many more that apply directly to body work.

The body engineer of today cannot limit his job to satisfaction of the stylist's concept, Cronin stated. The design must be obtainable at a reasonable price, adaptable to low cost tooling and processing, adhere to standards of quality and stand up for the life expectancy of the car. The body engineer must work not only with steel but with glass, upholstery fabric, leather, copper and rubber. He must always remember that his design must be not only the most practical that can be manufactured, but also that it must provide fabrication and assembly in the easiest manner with the minimum of time, cost and effort.

According to Cronin, one of the most fertile areas for engineering improvement lies in providing close correlation between design and tooling to be sure that the design lends itself to the lowest cost tooling. Also continual research is needed to anticipate and solve the problems of the future.

Cronin sees the need for engineers to become better organization men, to become more effective in the skills of human relations; to develop to a greater degree the fine art of cooperation with others and the ability to inspire others with a desire to cooperate with them; to communicate their ideas more effectively to production men and to be more open-minded toward the ideas of production men and more mindful of their problems. The industry is looking for proficient engineers who have developed the production and executive viewpoint.

SAE Enrolled Students from Oregon State College in front of International Harvester Co. on their Feb. 17 field trip

Inspect Near-Complete Willgoos Turbine Lab

• Southern New England Section

R. E. Johansson, Field Editor

March 1—An introduction to the problems of transonic and supersonic aircraft design, together with a preview of the facilities for taming the "fire-breathing dragons" which will power these planes, provided an interesting twin bill.

A visitation to the Andrew Willgoos Turbine Laboratory of United Aircraft Corp., East Hartford, Conn. was featured in the top half of the day's program. A $12,000,000 project, the largest privately-owned jet engine laboratory in the world is nearing completion and is dedicated to the memory of the man who was chief engineer of Pratt & Whitney Aircraft for 23 years and who had a leading part in the shaping of the plans for the jet test center. By mere coincidence, the tour took place exactly one year from the date of Mr. Willgoos' passing.

The group heard **B. A. Schmickrath,** chief, experimental test laboratories and **Carl Kopplin,** project engineer, describe the lab's pertinent features. They estimated that the fortunate purchase at substantial discounts of four unused boilers scheduled for uncompleted Navy cruisers and twelve turbogenerators at the end of the last war contributed largely to the saving of some $5,000,000 during the course of construction. The laboratory is six stories high, 166 ft. wide, 400 ft. long, and is situated on the Connecticut River. There is good reason for its location inasmuch as the lab will take in 120,000 gal. of water a minute, a rate nine times greater than the normal consumption of the city of Hartford. Warmed but otherwise unchanged by its brief part in jet engine testing, the water will cascade back into the river through a concrete sluiceway.

The principle, which has worked so well in the evolution of the Wasp line of piston engines, of component testing will be followed in this lab also. Entire engines must be tested, of course, but parts will be tested separately before combining them in the whole engine. There are four test cells at present in the new plant. One cell will test com-

pressors and contains a 21,500-hp electric driving motor rated at 15,000 rpm. Another cell will be used to test turbines or complete engines, and the other two cells will be used for testing burner components or entire engines.

The service pipes which supply the jet engine with air, and the power lines which supply the test equipment and instruments with electricity, run from the large center portion of the structure. It is here that the four new boilers, refrigeration, air heating and cooling systems, air exhausters, and compressors are located. Air can be cooled to -70 deg. F. and supplied to the jet engines at a pressure equivalent to that found at 40,000 ft.

The Willgoos Laboratory's four steam-driven generators can each turn out as much as 5,500 kilowatts each. The electrical powerplants can more than light the city of Hartford with their flow of current. Because the generators can provide the main plant of Pratt & Whitney with part of its required power, a saving of some $100,000 a year is expected.

The roaring hot gases leaving the engine are cooled by passing through water sprays in the discharge pipes in the test chambers and then through three gas "scrubbers" on the service floor. Calmer and cooler by some 1000 deg, the air rushes through three exhausters and then has the noise strained out of it by being passed through one of three silencing chambers. The underground chambers are built of heavy concrete faced by sound absorbing material. More of the remaining jet sound is lost in a labyrinth before the gas is passed into the outer air through slots set in concrete bunkers. The solid blank walls of the building were also designed to hold in the noises. Pratt & Whitney Aircraft has spent some $1,000,000 on soundproofing their jet-engine test equipment.

Following the tour, the group held its evening session at which times **Carl E. Reichert**, chief, design branch, Aircraft Laboratory, Air Materiel Command, spoke on "Supersonic and Transonic Aircraft Problems."

In the lively question period following his talk Reichert commented that what is really needed in military aircraft is a quick-change-of-pace plane.

Furthermore, in answering a query on Russia's apparent copying of U. S. equipment, Reichert stated that probably "copying" is the wrong term. He felt that no one country has a monopoly on brains. Therefore, it is quite possible that these two countries are groping along the same paths and are reaching certain landmarks at approximately the same time. The use of propellers rotating at speeds in the supersonic range were considered easily feasible, inasmuch as they are basically airfoil sections which have been proved to be satisfactory in this range for aircraft.

Finalists in student technical paper competition sponsored by Chicago Section: Center: F. G. Hogshead of Aeronautical University, first prize winner; left: Jack Roman, Northwest University; right: Lee Hardison, Illinois Institute of Technology

Ladies Night Features Experts

• Washington Section
Milo F. Snider, Field Editor

March 21 — Annual Ladies Night brought a panel of experts to the Washington Section. Moderator of this sees-all, knows-all panel was W. K. Knauff, Department of Agriculture, and its members were:

H. D. Hoekstra, Civil Aeronautics Authority; Hoy Stevens, American Trucking Association; W. C. Bauer, Briggs Filtration Co.; E. F. Fiock, National Bureau of Standards; and C. S. Bruse, National Bureau of Standards.

Hogshead Wins Student Paper Prize

• Chicago Section
K. H. Jacobs, Field Editor

March 21—Chicago Section held its first joint Section-Student meeting tonight on the campus of Illinois Institute of Technology. Arranged as the beginning of an annual series of such meetings, the session was notable for two special events:

(1) Final awards were made in the student technical paper competition fostered by the Section; (2) Wilbur Shaw, president of Indianapolis Speedway, made the main address.

Fred Hogshead, Aeronautical University, won first prize in the student paper competition with his paper discussing the engineering approach to a combination automobile-airplane. The other finalists, who also were winners of competitions in their respective schools—and whose papers went to the Section Governing Board for final consideration—were Les Hardison, Illinois Institute of Technology, and Jack Roman, Northwestern University.

Shaw told thrilling tales from his career as a race driver and automobile racing enthusiast and showed an interesting color-film, "Behind the Checkered Flag." Questions which followed indicated the nation wide interest in the annual Memorial Day race.

Hollister Moore, manager, Membership & Sections Division, SAE Headquarters Staff and Chicago Section Chairman Orville A. Brunner also spoke briefly.

Sandham Tells of Gilmore Run

• Northwest Section
K. A. Short, Field Editor

March 10—The missing element in the gasoline economy picture, said **Wilmot Sandham**, automotive engineer, General Petroleum Corp., is knowledge of the attainable level of mileage, and ways to reach it. The information would benefit the automobile builder, the car dealer, the oil industry, and the customer.

The good job being done in automotive engine improvement is showing up in some cars in improved miles per gallon, in spite of power losses from automatic transmissions, soft tires, and the like. In other cars, engine improvement has helped offset these negative factors.

To show what can be done with stock cars, tuned, equipped, and adjusted within factory recommended tolerances, and operated within legal limits, is the purpose of the Mobilgas-Grand Canyon Run, said Sandham, Attention-getting and eye-catching features are deliberately provided to command notice, and get public consideration of the results.

Sandham pointed out that the rules were set by the contest board of the American Automobile Association, with the intent that the run was to simulate one which any car owner might take his family on for a week-end trip. No trick driving, such as de-clutching or

Northrop Aeronautical Institute students at Herrmann Engineering Co. in Glendale, March 25. The Herrmann cam engine is in the foreground

coasting with the car out of gear, was permitted. It was necessary to stop at all stop signs, and timing was regulated so that normal speed had to be maintained. Cars were all 1950 four door sedans, which could not have been driven over 5000 miles, and only one of each make and model could be entered. Great care was taken to insure that cars were standard in every respect, including disassembling of motors, carburetors, distributors, and checking against factory specifications. Cars carried four passengers, and were carefully fueled on level concrete pads.

High-Speed Air Transport Growing

• Southern California Section
R. E. Strasser, Acting Field Editor

Feb. 23—To explain development of high speed air transport, **Frank W. Davis** of Consolidated Vultee Aircraft Corp. reviewed the modes of transportation from their earliest forms to those in the future.

Scheduled air transport is said to have started in Germany four years prior to World War I with the use of Zeppelins carrying passengers between the larger cities. As late as 1935 authorities were still predicting that the Zeppelin would handle the larger part of air transportation over long distances.

Davis introduced the term "tub to tub time," meaning the time required to go from home or office in one city to home or office in another city. While the time from one airport to another is being reduced, in many instances the total time spent on the trip can be increasing rather than decreasing due to the increased time required to get from the airport to the office. Davis feels it better to reconize this fact in figuring the time of trips than just the time from airport to airport.

For the future, Davis sees speed as a desirable commodity and thinks that serious compromises of safety are neither tolerable nor necessary unless some new departure is undertaken.

The most advanced means of travel would be by rocket, Davis said, though this is impractical at present. The next best step would be ramjets and these also are not practical at present. The next move would seem to be to turbojet transportation. Principal reasons for not having turbojets now are that development costs are high, most airlines are fairly well supplied with expensive modern equipment which would require replacement, and "tub to tub time" would not greatly be increased, particularly for short range traffic. Most desirable, it seems, is a development which promises a reasonable speed improvement with a minimum of financial risk. The turboprop powerplant installed in presently available airframes meets these requirements.

Oil Analysts Name Engine Complaints

• British Columbia Section
J. B. Tompkins, Field Editor

Jan. 16—If engines could talk, they would tell maintenance men where they hurt, and why, said **D. H. Seiter,** manager of Faber Laboratories, Seattle Wash., talking on "Lube Analysis and Its Effect on Economy of Operation."

Crankcase oil analysts are able to determine the things engines would like to complain about but can't. Under specimen reports headed Fuel Dilution, Solids Volume, Viscosity, Foreign Matter comprising Metal, Water, Gum Tars and Residues, Fuel Soot, Free Carbon and Dirt or Sand, Crankcase Operating Temperatures and Type of Dilution, breakdowns of oil samples point directly to localities where trouble exists. Specific causes of faulty performance are often exactly indicated.

Oil analysis, he pointed out, is not a substitute for preventive maintenance programs. But periodic sampling, when coupled with planned P.M. schedules, can furnish a satisfactory answer to the problem of detecting developing trouble before serious damage has been done to moving parts.

Where reasonable daily and monthly maintenance programs are observed, he cited 4,000 road-mile, or 3,000 motor-mile intervals as practical times for performance of oil analysis. That period, explained Seiter, applies in cases of passenger cars and light trucks. Large trucks, he continued, will profit if analysis is undertaken following consumption of each 400 gallons of fuel.

Though providing satisfactory relief from excess heat for cylinder walls, Seiter said, water coolants afford little protection to pistons and valve stems menaced by combustion temperatures. Safety for moving parts hence depends upon the cooling action of crankcase oil. Again, cleanliness and proper viscosity are imperative.

Continuous oil films on all contacting surfaces reduce, or at least stabilize, inter-engine reciprocal forces setting up vibrational waves. Lubricants inadequate in other duties may contribute to early failure of moving parts through permitting vibration to persist to a damaging degree.

Additives came into the picture after development of modern automotive engines, whose faster-moving parts intensified existing heat problems. Detergents, anti-oxidants, pour-point depressants, gum inhibitors, viscosity stabilizers, anti-foam agents and oiliness agents all comprise additives aiding lubricants in their function.

Maintenance men had little reason to fear formation of gum in the engines of years ago, Seiter told his listeners. While straight-run gasolines sufficed to fill the automotive needs of the day, he explained, gum deposits were all but unheard-of. Refinery men first developed the cracking process to enable them to supply ever-increasing demand for automotive fuel. Cracked gasoline is produced from deeper-cut crudes. It is from combustion of these fuels that gum deposits result.

It is fallacy, said the laboratory, man, to believe that all must automatically be well with motors enjoying frequent changes of oil. It is imperative that the lubricant be adequate for the particular job for which it is used. You can't, he observed, cure a cancer by frequent bandage-changes.

James Gives Hints For Saving Gasoline

• St. Louis Section
G. C. Husbands, Field Editor

Feb. 2—**W. S. James,** vice-president of engineering, Fram Corp., and past-president of SAE, spoke on "Economy of Operation as Influenced by Engine, Transmission, and Body Design," before a joint meeting of SAE and the Engineers Club of St. Louis.

Wind and rolling resistance, internal friction, driving habits, and traffic

systems affect economy of operation of the automobile, it was shown by slides and explained by James. Also it was shown that better engineering with regard to lower heat losses and power absorbed by accessories can improve economy.

A saving of 1% in the amount of gasoline used by the motoring public would run into millions of gallons per year. This could be accomplished by periodic tuneup of the engine, better driving habits, and proper tire inflation, emphasized James.

Reports Findings Of Wind Tunnel Tests

• Wichita Section
Don Simon, Field Editor

Feb. 16—"The Automobile in the Air" was the subject of **Prof. Kenneth Razak**, director of engineering, University of Wichita, for the meeting held jointly with the I.A.S. Wichita Section, at the Polar Bear Restaurant.

He told how eleven modern cars, were tested in the University of Wichita wind tunnel with correlated road tests to investigate the nature of flow around the moving car. These tests conducted for Nash Motors indicated average air drag power at 60 mph. of 22.4 hp with the range 18.1 to 27.4. The lowest drag car was over 20% better than the average, and air drag differences as high as 51% were noted. The automobiles tested were selected to represent aerodynamically nearly all the cars being produced in mid-1949. Air drag equalled rolling resistance due to tires and bearings at an average speed of 43.5 mph. At 60 mph as much as 64% of the total engine power developed was used to overcome air drag, and at 80 mph the maximum was 73% of the engine power.

Shape of the rear end of the car, he said, seemed to be the major factor contributing to air drag. In general, notch-back cars had higher drag than cars with the slipstream back. From 1 to 2% reduction in drag was accomplished by shielding the front wheels. Streamlining the underside of the car decreased drag only 6%. Another source of drag is the front end shape. It appears that the forward-most structure of the car determines the amount of air crowded under the car with most going over the top or around the side. Two of the cars had exterior sun visors. A drag increase of approximately 9% was measured in each case. At 60 mph this costs 2 to 3 hp.

During tunnel tests two cars were noted to have vibration on the scales. This vibration at about 3 or 4 cycles per sec could easily be felt by passengers in the car. The turbulent flow which occurred over the rear of the car was found to produce an oscillating pressure pattern. This same effect was noted on the road.

These tests, Razak stated, indicated the possibility of increasing car performance, reducing fuel consumption and lowering wind noise by proper attention to aerodynamic characteristics of the exterior.

Evaluates Modern Propulsion Systems

• Western Michigan Section
R. F. Allison, Field Editor

April 10—The advance of transportation, which had been gradual before World War I, was then given an impetus that resulted in great strides—particularly in the field of aviation. This accelerated improvement continued until planes powered with reciprocating engines and propellers had reached a point where propeller tip speeds were approaching the speed of sound. At this point power requirements increased abruptly and the development of faster aircraft would have been at a temporary impasse, had the jet engine not made its appearance.

Enlarging on this outline in his talk "Modern Systems of Aircraft Propulsion," with the aid of slides and movies, **Lt.-Col. Paul F. Nay,** USAF, Air Materiel Command, Wright Field, showed how jet development had opened a new era of flight in which it is presently impossible to predict the limits of speed.

The jet-propelled aircraft, coming as it did in the early days of World War II, naturally was developed at a rapid pace. In 1940 the Caproni-Campini made the first flight to reach public notice, although it is believed the Germans made jet-propelled flights earlier. Colonel Nay named the six major types of power plants as Reciprocating, Turboprop, Turbojet, Ram- and Pulse-jet, Rockets, and N. E. P. A., the latter still under strict secrecy for security reasons. The Turboprop engine will be widely used commercially, the speaker believes, when and if a supersonic propeller is developed. This type of engine has a much lower specific fuel consumption than any of the other types of jet engine.

The Turbojet is the type most widely used for sustained flight. Both axial and centrifugal types of compressors are incorporated; the former lends itself much better to streamlining of fighter type planes, and is more efficient. The Ramjet produces the greatest thrust of any of the jet engines, up to 40,000 lb above sonic speeds. This type requires air speed for its operation and cannot be operated statically.

Rocket engines are not dependent on atmospheric oxygen since they carry their own oxidizing agent as well as fuel. This factor removes them from any restriction imposed by altitude. Both liquid and solid fuels are used in rockets. The solid fuel type is used mostly for assistance in plane take-off, as its burning, once ignited, is uncontrolled.

In conclusion, Colonel Nay emphasized that he had only partly covered the development of jet propulsion, and the fact that this source of power is still only in its infancy.

Safety, Accuracy Mark Proving Ground Work

• Southern New England Section
Robert E. Johansson, Field Editor

April 5—"Year to year records substantiate the fact that it is ten times safer to drive at the General Motors Proving Grounds than on public highways." This statement, together with numerous other factual data concerning automotive testing at GM's outdoor laboratory, gave members of this Section a new insight into this field of automotive endeavor as Louis C. Lundstrom described to a capacity group the facilities of the Proving Ground and the part it plays in the final evaluation of a new automobile.

Lundstrom is head of the mechanical engineering department of the Proving Ground Division of the General Motors Corp. Despite popular belief that a proving ground would necessarily entail "stunt driving," Lundstrom emphatically stated that such was not the case. Instead, all automotive testing is done by people who put new cars through paces which would be experienced day in and day out by the average public.

Only complete units are tested at this laboratory. Each General Motors division conducts its own test independently, and competition is keen. The greatest secrecy exists prior to the disclosure of a new model, even between divisions of the parent organization.

There are some 25 miles of roads on which cars may be tested in the 1628 acre site. These roads vary from smooth super highways to mud bogs and water traps, from flat curves to climbs of some 27% grade. Steeper climb grades of 45% and 60% are available for military testing.

Fleets of cars are tested at one time and each day some 25,000 to 30,000 car miles are registered at the Grounds. Durability testing takes precedence over all other types of testing. Runs are made which continue straight through the 24 hours of a day, day after day. This testing is done on a definite schedule, and no car is run to destruction. It has been ascertained that such a test run for 25,000 miles is equivalent to 50,000 miles of public usage. The capacity of the Grounds is demonstrated by the fact that 30 cars may

be tested per month with each having 25,000 miles put on it.

The next type of testing, engineering tests, includes items such as fuel consumption, hill climbing, braking tests, acceleration tests, and so forth. Once again fleets of cars are devoted to these tests. General Motors products are carefully checked against current models of competitive makes of cars and also against past records of tests conducted on previous models of GM cars. Most of these tests include ingenious devices for the measurement and evaluation of test data; however, one of the tests which attempts to determine the "roadability" of a particular car is decided by a panel of experienced personnel relying on personal judgment.

In adverse weather, testing continues in the indoor facilities. Here visibility checks are made which are an important source of information to the designers of the new models. Weight analysis is another important part of the work, and complete cars are disassembled and each and every part weighed individually down to the last bolt and screw. A summation of the individual weights thus obtained compares with the assembled weight within plus or minus 3 lb . . . an outstanding example of the meticulousness of the analysis.

Physical dimensions of the testing plant were enumerated and it was noted that as many as 12 types of gasolines may be had at the refueling station at any given time. The Proving Ground uses some 10,000-12,000 gal of gasoline per week.

In the question period, conducted by Seth H. Stoner, chief engineer of the New Departure Division, GMC, and technical chairman of the evening, Lundstrom stated that durability-wise, the low priced cars were on an equal with their more expensive brothers.

Correction

Two typographical errors were made in the article "Status Quo Urged for Rating Antiknock of Aviation Fuels," pp. 78 and 79, April, 1950, issue of the SAE Journal. First, in the top paragraph of the first column of p. 79, the article should have read "1.0 ml per liter" instead of "1.0 ml per Btu." Second, in last paragraph of article the first sentence should have said "82 8½ × 11 pages" instead of "82 ½ × 11 pages."

Diesel Improvements Increase Highway Use

• Pittsburgh Section
Murray Fahnestock, Field Editor

March 28—Acceptance of the diesel engine for highway vehicles has accelerated greatly during the post-war period, said **Merrill Horine**, of Mack Mfg. Corp. Today's diesels add but little to overall weight to secure equal performance, and they can be installed in the same space, while the range of useful operating speeds has been broadened to nearly match the flexibility of heavy-duty types of carbureted engines. Modern automotive diesels have been smoothed out so remarkably it is often difficult to distinguish between them and prevailing gasoline engines.

Despite widespread misunderstandings, fuel economy and only fuel economy constitutes a major advantage. Horine showed a number of novel charts showing relation between "vehicle miles per gallon" and the additional first cost of diesel equipment, to prove that diesels could provide important reductions in total operating costs, at much lower mileages than the 50,000 miles per year often quoted.

Speaking of the impression that diesels were difficult to operate and more difficult and costly to maintain, the speaker said that true as this was 15 or 20 years ago, it is emphatically not so today. But for a trifling difference in the controls for starting and stopping the engine, there is nothing in the driving of a diesel-powered vehicle by which an experienced driver could distinguish one from the other.

Savings by reason of fuel economy are consistently about 50%, said Horine, so that in any operation where the annual fuel expense exceeds twice the interest and amortization on the additional price of the diesel powered vehicle, an overall saving is indicated. We can reject the effect of additional weight on fuel consumption, since it is allowed for in the general saving in fuel consumption and, since engine weight is practically all on the front tires, which are already underloaded, it will not affect tire costs.

Weight-conscious fleet operators value payload capacity at $1.00 per lb per year in long distance hauling, so we may consider the extra weight as dollars, to be substracted from the net saving in fuel costs.

It is now generally understood that diesels require for best operation a specialized fuel about as critical as gasoline for gasoline engines. A heavier fuel is preferable, if the engine can use it, as it contains more Btu's, has better lubricating qualities and creates less smoke and less odor. The speaker mentioned a large city bus operation, where the engines operated on part throttle or idling conditions 50 seconds out of a minute, as a factor in some operations.

Answering E. B. Kerekes of Elliott Co., regarding the reported higher fuel economy of foreign built diesels, the speaker said that fuel costs had always been so high in Europe that greater attention had necessarily been paid to fuel economy and that, in countries where the tax collector outranked the engineer and adequate weight was severely penalized, engines might be lighter per horsepower, but they were rougher and required more maintenance service, in countries where low wages were paid.

Technical Chairman John Kobzina agreed with the speaker on the need for hospital cleanliness of the fuel supply for diesel engines, owing to the microscopically small clearances of some of the working parts. The pump plunger and barrel are fitted to 125 millionths of an inch and the nozzle valves are but little less fine. It does not take a very large abrasive particle, therefore, to ruin parts such as these.

Answering the question regarding the use of the diesel engine for retarding the vehicle on steep grades, the speaker replied that this was largely dependent upon the type of fuel injector used. Some fuel injectors are lubricated only when the fuel flows through them, and even a slow flow of fuel into the engine destroys the braking power. But this is eliminated if the fuel is by-passed by the moving parts back into the injector when the throttle is closed. Then the diesel engine is said to be more effective because of its higher compression ratio, than a gasoline engine.

Plant Visit Voted High Spot of Year

• Central Illinois Section
Ivan Lamport, Field Editor

Jan. 23—Central Illinois Section members were guests today of the Keystone Steel & Wire Co., the largest independent wire mill in the world today, of Bartonville, Illinois. An impromptu inspection of Keystone's new and modern office building was followed by a turkey dinner at 6:30 pm in the Keystone cafeteria, at which time souvenirs were passed out to the guests. Immediately following the dinner a short movie was shown and then Lou W. Hesse of the Keystone Public Relations Department welcomed the guests on behalf of the company and assigned them to guides.

The first part of the trip covered the departments primarily concerned with producing finished products from the great coils of rod. Here huge coils of rod are first cleaned, then limed and baked. Then the rods are cold drawn into wire of many sizes which were then heat treated and plated.

Next came the wire nail department (an extremely noisy place), the gal-

vanizing and galvannealing department and the fence weaving division. Of extreme interest was the barbed-wire-making machine. Here two separate strands of wire are each "barbed", then twisted together and rolled into a coil. These operations are so fast that the winding spool can be seen only as a blurr.

Members also saw the open hearth furnaces where scrap is being made into ingots. From there they travelled to the soaking pits and the blooming mill and watched ingots being rolled into billets. Last came the rod mill where the billets are heated and rolled into rods. Despite rain and mud, every one who came voted the trip the high spot of the section year. Technical Chairman for the evening was R. S. Frank, of Caterpillar Tractor Co. Engineering Department.

Transonic Flight Viewed by SAE-IAS

• Metropolitan Section
J. D. Waugh, Field Editor

March 16—Physicists must take the leading role in exploring the phenomena of the trans-sonic range of airplane flight. This was the majority opinion of six aeronautical experts who contributed to the all-day symposium on high-speed flight in a joint meeting of the Metropolitan Sections of the SAE and Institute of the Aeronautical Sciences.

Defined as the range from 80 to 120% of the speed of sound, the trans-sonic range is where, when entering, the drag becomes extremely severe, and tends to decrease when beyond that sped.

A force existing at 150 mph may be small compared with the weight or moment of interia of the aircraft, but at 600 mph the effect of this force may be multiplied by 16. Hence, tolerances acceptable on low speed aircraft are untenable for high-speed craft, it was pointed out.

One of the contributors to the three session symposium described the work done to overcome the ill effects of critical Mach numbers on aircraft and pilots, who, he said, have nicknamed these phenomena "machs."

Pilots of this company have reported that the most severe "machs" are those causing airframe shakes which they feel violently on the seats of their pants, rudder roughness felt by severe perking of the pedals, and longitudinal porpoising which they feel throughout their bodies.

Airframe engineers were warned that there is no such thing as an "all-speed turbine," because turbines must be designed to produce a given output at a given speed.

When an airplane must be designed to take off, gain altitude rapidly, pass through the critical Mach numbers,

25 Years Ago

Facts and Opinions from SAE Journal of May, 1925

Over 50 active members in the Los Angeles area have petitioned the Council for authority to establish a Section there. . . . A most active informal group has been maintained in Los Angeles for many months. . . . The industrial activities of Southern California are carried on by live companies in which many Society members are prominent. . . . It is probable this petition will be granted and the Section inaugurated sometime in May.

■

In a vivacious and amusing extemporaneous talk, C. F. Kettering told a large gathering of the Detroit Section on April 2 about a wide variety of things. . . . He said that many people think the world would be a sane place if engineers weren't always changing things . . . that the engineer will lose has job only when he has conquered all of the forces of nature . . . that the greatest difficulty in business is to get men to use their imaginations . . . that there are some new forces we know nothing about . . . that we are just beginning to learn to think . . . that the engineers big job is to have visions of tomorrow.

■

A new type of finishing material using a type of nitrocellulose known as pyroxylin was described by J. J. Riley of DuPont at a New England Section meeting. Two first-class workmen should be able to do a car refinishing job with this material in a day and a quarter, he said.

■

Speaking of diesels, Philip I. Scott, Super-Diesel Tractor Corp. of La Porte, Ind., noted three classes of service which exist for diesel application in United States: (1) self-contained rail car units of 100 hp, having 40 to 60-passenger capacity; (2) a short-haul unit of about 300 hp; and (3) a large locomotive of 1000 hp, or more for freight and passenger service. . . . Research is being conducted, he added, to fit the diesel to the automobile, the motor truck, the tractor, and the airplane.

■

Around the world from Seattle to Seattle by air westward (27,553 miles) covered in 175 days is the epochal event accomplished by fliers of the United States Air Service that was vividly pictured before the SAE Washington Section at its April 24 meeting.

■

In answer to that oft-repeated query "When do we go back to White Sulphur Springs?" the Meetings Committee has practically completed final plans for sessions and events of the Summer Meeting, June 16 to 19, 1925 at that delightful meeting place.

■

A range of more than 2 to 1 at present prevails in the belt velocity of tractors, some being designed to run at 4100 fpm, whereas others operate at 1900 fpm, L. H. Letz Mfg. Co. said at the National Tractor Meeting in Chicago.

■

Storage Battery Division of the Standards Committee has recommended that the present SAE Standard for Storage Batteries be revised to specify a 20 hr instead of a 5 hr time rating. The change was voted only after a lively discussion.

■

Reasons for oil dilution, SAE Research Department reports, are now well known and may be classified as follows: (1) Heavier fuel particles find their way from combustion chamber past the pistons into the crankcase oil, and (2) Water, part of the product of combustion, finds its way past the pistons into the crankcase. . . . One immediate result of the contamination of oil is the occurrence of a sludge at the bottom of the crankcase.

■

The output of batteries per pound of weight has been increased in the last 4 or 5 years between 15 and 20%, said T. R. Cook, Westinghouse Union Battery Co., answering a Metropolitan Section questioner. Any advantage of increased length of life attained, he added, has been more than compensated for by the decrease in the size of the battery on the car.

■

The knuckle-joint press is now being extensively used to form articles from brass rod or bar, as well as in flat work and on brass casting shapes or forms. The present-day knuckle joint press has been much improved in design. (Information given at National Production Meeting by H. J. Hinde, Toledo Machine & Tool Co.)

and then travel in the super-sonic range where not as much power is needed, turbines as known today lack the versatility demanded of them.

Although variable turbine blade angle changing during operation was hinted at in discussion, the mechanical actuating system which would be required appeared too baffling at the present state of the art to warrant serious considerations.

Speakers at the morning session were **Verne Outman**, McDonnell Aircraft Corp., St. Louis; **W. Vincent Hurley**, Gas Turbine Division, General Electric Co.; **Robert Liddell**, Republic Aviation Corp.; **Joseph Platt**, Air Materiel Command, USAF; and **Arnold A. Redding**, Westinghouse Electric Corp.

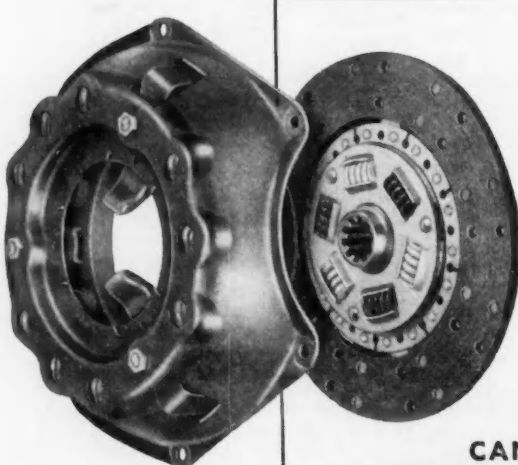
Co-chairmen of the meeting were Gordon W. Mackinney, SAE Section vice-chairman for Aeronautics, and Costas E. Papps, secretary of the IAS Metropolitan Section.

Philip B. Taylor, partner of Sanderson & Porter, was technical chairman of the evening session. He opened the session by having summaries of the day's proceedings recounted. Then the airframe members of the panel launched a discussion of control requirements for high speed flight.

Questions from the floor ranged from passenger comfort to engine performance. The panel was asked if passengers would have to wear football helmets to avoid injury due to buffeting at high speeds. An airplane expert assured the questioner that passengers would be safe from such shocks because they would be flying at a high altitude where gusts are infrequent.

Engine questions related to higher power, thrust augmentation and using the power plant as a source of cabin air. The engine men were unanimous in their opinion that the jet turbine should not be considered a source of bled air. This imposes a penalty on the performance of high compression ratio engines. Exhaust reheat was termed the best form of thrust augmentation.

Engine power increases were anticipated and improvements in design were promised. Aerodynamic excitation was called the cause of vibration fatigue failure of turbine compressor blades. Studies are under way to reduce such effects and increase power. The engine men defended attacks on the fuel consumption of turbines by pointing out the very high power output obtained from such a small unit. A stationary power plant turbine was used for contrast in fuel consumption and power output. The aircraft unit used only slightly more fuel in producing the same power, with a weight equalling one ten-thousands that of the stationary plant.



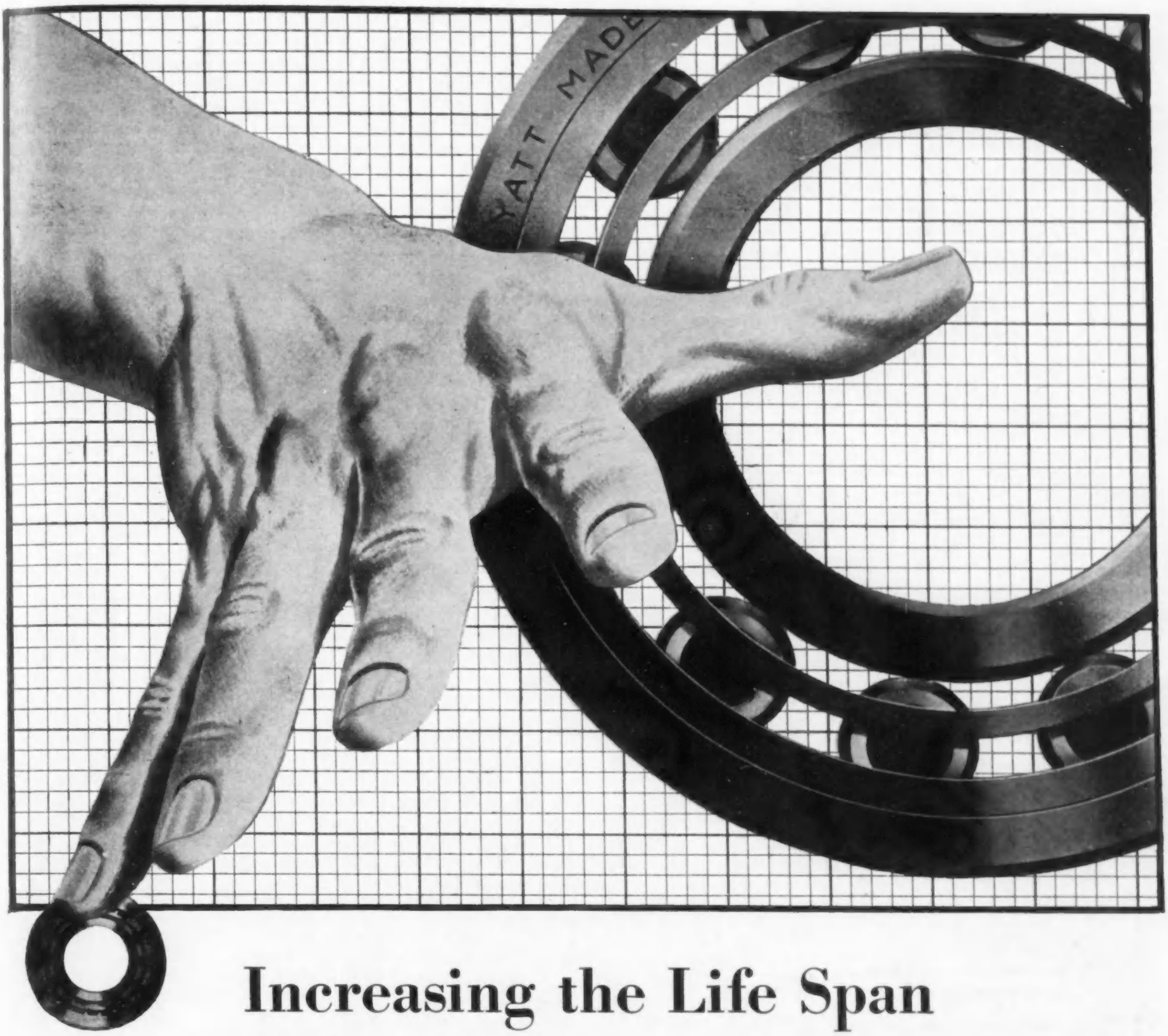
Economy, Not Power, Europe's Diesel Aim

• Kansas City Section

K. J. Holloway, Field Editor

March 14—European engineers design toward obtaining maximum economy rather than maximum power from diesel engines, **George A. Round**, chief automotive engineer, Socony-Vacuum Oil Co., pointed out in discussing new developments in European automotive engineering. High cost of fuel plus intolerance of exhaust smoke and fumes in European countries have dictated design along these lines.

Pronounced swirl of intake air to assure intimate contact of all fuel with clean fresh air, use of "squish" type pistons in open combustion chambers, and de-rating engines are among the devices used to obtain fuel economy superior to that of U. S. diesels. Surprising economy is obtained even



though European diesel fuel is inferior and higher in sulphur content than U. S. fuel.

The European diesels handle this inferior fuel cleanly and economically. Little ring sticking is encountered and wear is low although little heavy duty detergent oil is used. These characteristics are at least in part due to good handling of fuel in the combustion chambers and to relatively low piston temperatures obtained by using aluminum pistons.

European designers are also working toward diesel engines which will idle quietly. By using an unconventional contour cam, pilot injection is obtained. A small amount of fuel is injected and ignited prior to introduction of the main charge. This appreciably reduces the noise caused by the delay in start of ignition after injection is started with normal injection.

Round also discussed a 5 cyl diesel engine which is popular in England a small 1600 lb front end drive Swedish car with individual wheel suspension and torsion bar springs which displayed outstanding roadability and a French bicycle engine capable of 600 mpg of gasoline.

Design Against Detonation Urged

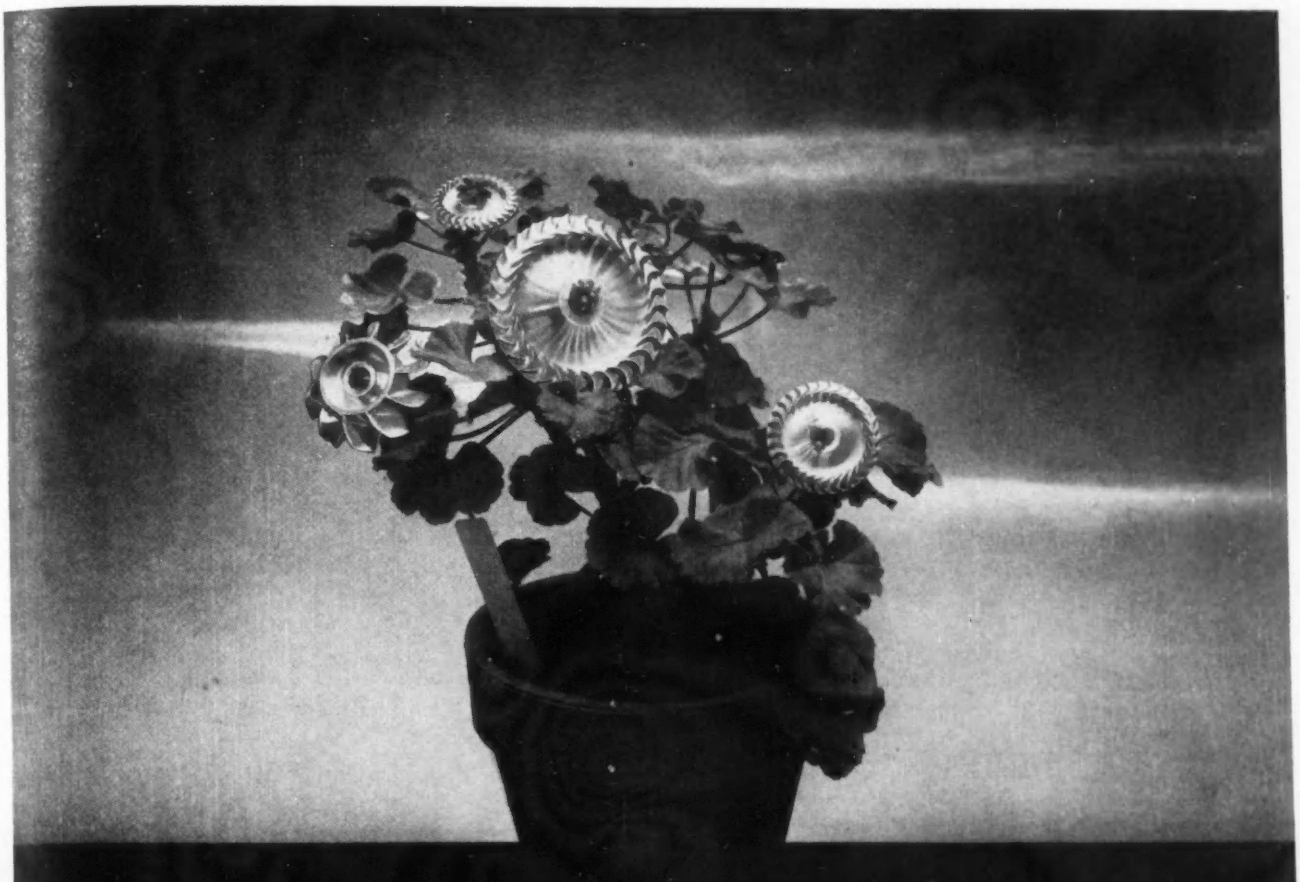
• Williamsport Group
William Ribando, Field Editor

March 6—Alex Taub says it is better to eliminate detonation by combustion chamber design than by internally cooling the engine by fuel. Now is the economical time, he urges, to make this change. Taub pointed out that:

It is agreed that higher compression engines save fuel but a dispute exists about the way detonation is to be overcome. So far, detonation has been overcome chiefly by cooling or wetting the hot spot or source of detonation with excess fuel. This in itself necessitates a waste of fuel and requires special fuels with higher octane ratings which require special expensive processes.

Equal or better results may be had with properly designed combustion chambers which eliminate the so called hot-spots. Non-detonating engines can lead to more fuel availability by permitting higher compression with regular fuels—and they do not require restriction in fuel production as is necessary with the production of high octane fuel.

In addition to detonation that may follow an increase in compression ratio, combustion roughness may occur which is the result of increased rate of acceleration of the pressure rise. This roughness can be partially controlled by shaping the main chamber so that the area of the flame front would progressively decrease after the total volume burned has reached 35%. This residual of combustion roughness not removed by combustion chamber design



must be compensated for by additional engine rigidity (that is, crankshaft and maximum number of main bearings), decreasing the stroke of the crank and increasing crankshaft diameter.

Elimination of valves by adoption of a sleeve mechanism; use of a single valve, serving both as intake and exhaust valve that could be subjected to better cooling; and improved combustion chamber contour are means to reduce hot spots and permit the use of higher compression ratios.

Many successful experimental engines incorporating these design changes have already been developed but not accepted by engine manufacturers due to the high initial tooling costs believed to be entailed in a changeover. It is believed that tooling costs for present engines have already been absorbed by industry and that savings resulting from use of low octane fuel will more than offset any additional costs necessary for a changeover at this time. The trend already has been set by a few engine manufacturers and will of necessity be followed by others.

Lower Ton-Mile Costs Are Sought

• Oregon Section
Jesse M. Roseberry, Field Editor

March 15—Lower cost per ton-mile is the automotive engineer's answer to demands for greater economy and more luxury in cars, **Wilmot Sandham,** General Petroleum Co., told listeners in a talk on "The 1950 Mobil Gas Grand Canyon Run". A thorough program of driver instruction is needed, he said, to bring about generally economical operation of cars.

Section Chairman Floyd D. Chapman presided at this dinner meeting which was held in the American Legion Post #1 Hall in Portland.

New Studebaker Transmission Topic

• South Bend Div., Chicago Section
R. L. Smirl, Field Editor

March 20—At least five main objectives were reached in the new Studebaker automatic transmission design, M. P. deBlumenthal, Studebaker experimental engineer, told listeners at the last technical meeting of the season of the South Bend Division, Chicago Section. These objectives were:

(a) down-hill engine braking equal to or better than second gear in a sliding gear transmission; (b) no creep with car stationary and in gear; (c) lock-out of reverse while car is in forward motion, yet retaining ability to "rock" to free car from snow and mud; (d) taxi push for starting the engine at relatively low speeds; and (e) me-

chanical parking lock.

He went on to discuss the major elements of construction of the new transmission, covering many of the same points as were made by H. E. Churchill in his discussion of this design on pp. 20-26 in the March, 1950 SAE Journal.

deBlumenthal completed his talk by emphasizing the accessibility of the various components of the new transmission for servicing. Churchill acted as technical chairman of the meeting.

Traces Diesel Electric Locomotive Progress

• Oregon Section
Jesse M. Roseberry, Field Editor

Feb. 17—The diesel engine in the locomotive is making railroad history in the rugged Northwest Territory.

Jack Rutherglen of General Electric Co. detailed the history and development of the diesel electric locomotive in the two and four cycle engines, at an Oregon Section dinner meeting held at the American Legion Post #1 Hall, in Portland.

Discussion period revealed a fact few automotive men realized . . . that railroads are going all out for diesel electric powerplants in yard, passenger and freight engines. Union Pacific Railroad couples two and three units together regardless of make or vintage to operate as a single powerplant through the control panel of only one of the group. Full horsepower is available from starting to high speed. In fact enough power from three units is available so that when starting a long train the draw bar can easily be pulled out of a car, breaking the train in two.

Attendance at this meeting included fleet men, truck and engine distributors' representatives and members. Prof. William H. Paul and many of his SAE Enrolled Students from Oregon State College were guests of the Oregon Section's well known Friday noon luncheon at Lloyd's in Portland. The group then visited the S. P. & S. Railroad's diesel-electric shops at Vancouver, Wash. one of the nation's outstanding shops of its kind. The dinner meeting completed an instructive field trip for the Oregon State College Student Branch.

STUDENT NEWS

Oklahoma A & M College

Rising to the defense of the petroleum industry, Dr. Frey, manager of oils and related products for Deep Rock Oil Corp., reviewed the demands of engine manufacturers for higher actane and cetane fuels on March 23.

The present octane rating of premium gasoline rests at 88 with an increase visible on the horizon, but we are now at a point where the manufacture of higher octane fuels would be very difficult.

Pointing to the automobile manufacturers, Frey indicated that higher compressions are possible with our present fuels if engine designs were so adapted. The problem of eliminating the hot spot responsible for detonation has been solved by single and sleeve-valve engines. Inherent factors to detonation in our present engines lie in the position of exhaust valves in regard to the combustion chamber and to the cooling system. Cooling could be greatly improved both as to the quantity and the direction of circulation.

Turn to p. 100

ENGINEERING ACCEPTANCE OF ENGINEERED FILTRATION!

Performance-wise manufacturers seem to agree with WIX on the basic importance of ENGINEERED FILTRATION. More and more leaders, such as: Case, Oliver, Minneapolis-Moline, Wisconsin, Diamond T and Harnischfeger, are accepting WIX as original equipment. To them, the oil filter and its element are not mere accessories, but rather an extension of their own engineering concepts, which measure and rate equipment on the basis of "what it will do for the user".

Each year sees new concepts and improvements in WIX Filters and Filterefils, as research and engineering team up to provide constant, progressive development. Built-In Sealing Washers, Electronically Controlled, Micro-Pore Filtrant Construction, Lithographed, Rustproofed, Prick-Punched Containers are but a few of many improvements pioneered by WIX in replacement cartridges.

Nor does WIX interest stop with the production of filter products that deliver outstanding performance. WIX merchandising "know-how" provides the manufacturer who uses WIX Products with a program that contains decidedly interesting sales and profit possibilities.

We'd like to outline this realistic picture for you. Write — and a member of the WIX Engineering Staff will tell you the whole story.

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Still another factor for improvement is the thorough mixture of fuel and air.

Turning to the diesel field, Frey presented their requests for a higher cetane rating. Unfortunately the high cetane fuels differ from high octane fuels, and both can not be obtained from the same plant economically. The basic demand for a higher cetane number is to facilitate starting. Once running, the power developed is dependent on the weight of the charge and the fuel of high cetane number suffers in this respect due to its lower specific gravity. The effectiveness of ether capsule injection in starting was revealed as the best present solution.

Referring to the oil industry, Frey said nothing definite is known in regard to the quantity of oil available, but quality may deteriorate.

—H. F. Dick

California State Polytechnic College

The operating principles of Sperry's new simplified gyroscopic indicator, the Zero Reader, was explained by Lew Webel, aeronautical sales engineer, Sperry Gyroscope Co., El Segundo, Calif., in a talk on March 15.

A new type of gyroscopic flight instrument, the Zero Reader pieces together attitude, altitude, heading, and radio path information on a simple two element indicator which tells the pilot exactly how to move the flight controls of his airplane. This relieves the pilot of complex mental calculations on approaches and landings. It also simplifies enroute procedures thereby leaving more time to the problems of carrying out a successful flight plan.

A series of slide films, shown in conjunction with Webel's talk, demonstrated how the pilot flies his predetermined course by means of the Zero Reader. Webel pointed out that the Zero Reader may be used to maintain altitude and heading without the use of radio beams. This means that if the plane is flying in a vicinity where radio facilities are not employed or are out of range, the pilot will still be able to maintain his course by use of this instrument.

In short, the Zero Reader is an automatic pilot except that the human pilot acts as the servo unit, applying the force to move the control surfaces of the airplane.

—P. G. Garner

University of Oklahoma

Student Branch members saw 300 new products manufactured from petroleum for home and industry use at their March 8 meeting. George W. Cupit, Jr., chief chemist for the fuels inspection division of Oklahoma Corporation Commission spoke on "New Products from Petroleum" to 125 members and their guests.

Among products shown were new high powered fuels recently developed and soon to be used in gas turbines and jet engines; synthetic materials for piston rings and gears which often outlast conventional rings and gears; and resins, water softeners and plastics of various kinds.

—Douglas W. Holland, Field Editor

College of the City of New York

This Student Chapter joined with the Technology Intersociety Interfraternity Council on March 16 to hear John C. Hollis, assistant to the general manager of the Society of Automotive Engineers, speak on "Job-Getting Techniques."

His talk touched on methods for self-analysis, emphasizing the value of knowing your product (yourself) and of doing a real merchandising job with it. Phases of "the interview" were covered briefly, with instances showing the value of careful preparation for it.

A few pointers were given as to what would be expected and looked for on the job itself. Hollis stressed, in conclusion, that there is no job security

that can equal a knowledge of what you have to sell and how to sell it.

Ugo Volpi, Field Editor

Indiana Technical College

Thirty members of the Indiana Technical College conducted a tour through the engineering laboratories of International Harvester Co. on Feb. 3.

Wayne Bushman, public relations, orientated the group on the physical set-up of the engineering section.

R. L. Bacon, of the engineering section, led the group through the dynamometer laboratory, where engines of experimental design were undergoing various load tests. One experimental engine, two years in the making, was pointed out as having already undergone 30 days of continuous running at various loads. It is to be operated until some component of its mechanism fails through fatigue.

J. Zelzer, foreman of the pattern and machine shop, explained the functions of his department, where new ideas and refinements of truck bodies are brought to realization. This section is a complete factory in miniature with all of the necessary machinery for producing these models.

—J. F. Sbarra, Field Editor

Northrop Aeronautical Institute

As follow-up to a recent talk by Karl Herrmann on his cam engine, this SAE student group went to Glendale on March 25 to inspect the Herrmann Engineering Co. plant.

Student curiosity about this new light weight engine was satisfield as they saw the various engine parts and witnessed machining procedures. Attention was drawn to simplicity of design and assembly and to an unusual rate of acceleration and a low idling speed (250 rpm).

—Joseph Toth, Field Editor

Oklahoma A & M College

Early attempts to use gaseous fuels were unsuccessful, according to R. A. Darling of Cooper-Bessemer Co., who related the experiences and difficulties encountered with early dual-fuel engines before a recent Student Branch meeting at Stillwater.

Gas was introduced into the cylinder by direct injection into the compressed air. Difficulties caused by this method were solved in 1934 when gas was introduced directly into the air intake manifold. Still troublesome in the method, however, are pocket formation and erratic burning processes.

Most gas diesel engines today are 4-stroke cycle, because the 2-stroke cycle limits maximum obtainable compression pressure and causes timing difficulties.

Steady introduction of gas into the intake manifold by means of a header with short lines entering the manifold at each cylinder location is used on the engine operating at atmospheric pressure. Timed gas is used on supercharged engines, by a mechanical arrangement around the intake valve. Gas is admitted to the airstream only when the air intake valve is open.

Among advantages of the dual-fuel engine, Darling said, are lack of preignition; rare detonation; decrease in specific fuel consumption with higher bmep; and a homogenous mixture obtained on the 4-stroke cycle. Exhaust temperatures are about the same; the engine is quieter; oil consumption is less; and oil remains cleaner.

Richard C. Meyer, Field Editor

Oregon State College

SAE Oregon Section members were luncheon hosts to student members on February 17 during an all-day field trip that took them to International Harvester Co. to inspect service departments and the new Harvester trucks, and to the diesel-electric shops of the Seattle, Portland and Spokane Railroad to see a diesel-electric locomotive

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in operation. More was learned about diesel-electric locomotives at Oregon Section's dinner meeting that evening, when Jack Rutherglen, service engineer for General Electric Co., was speaker.

—Laird W. McKee, Field Editor

University of Illinois

Wilbur Shaw, president of the Indianapolis Speedway and three-time winner of the classic 500-mile Memorial Day race, entertained a capacity audience of students on Feb. 22 with "Behind the Checkered Flag," a color-sound movie produced through the co-operation of the Socony-Vacuum Oil Co. and the Speedway. The film revealed the great amount of planning and labor that is concentrated on race cars up until the end of the race, the thrills and suspense of the time trials, and the grand climax of the big show.

After the film, Shaw described vividly the 1931 race in which he not only had his car disintegrate in the time trials, but was sent into the race in a second car which was to take him past four other racers, into a skid, over the wall, through telephone wires, and finally into the hospital. A short time later, back in the pits, Shaw soon found himself behind the wheel again . . . this time to finish the race in the money.

In the question period following his talk, Shaw said that 4-cyl cars generally are more successful than sixes or eights because there are fewer critical parts. Engine failure in the 500-mile race, in which cars often reach 170 mph, is not uncommon.

—William Gibb

Applications Received

The applications for membership received between March 10, 1950 and April 10, 1950 are listed below.

Atlanta Group

David E. Morris, Jack S. Reid, C. E. Steed.

Baltimore Section

Capt. Walter C. Featherston, Harold E. King, Louis Joseph Steinitz.

British Columbia Section

Charles W. Barnes.

Canadian Section

Edwin Alfred Backlund, Stanley Brown, Arthur Ellis Cooke, William K. Ebel, Denis Pierpoint Edkins, Rueben Allen Harvey, L. Thomas E. Hill, Narcisse McKay, Frederick E. Newman, S. A. Sadiq, Frank Blashford Thompson.

Central Illinois Section

Robert A. Cumming.

Chicago Section

Joseph U. Biasiallon, Charles H. George, Hollis R. Hilstrom, Julius R. Koppelman, William P. Manos, M. G. McGregor, J. G. Mortensen, John Edward Nelson, Dean Sawyer Pierce, M. F. Sperry, James F. Vojtek, Arthur J. Volz.

Cincinnati Section

Joseph William Gehrum.

Cleveland Section

Clarence O. Bell, Walter J. Evans, Jr., Andrew F. Haiduck, Frank J. Michelbrink.

Dayton Section

Jack Alford Clark, Marvin Davies Vance.

Detroit Section

Newell P. Beckwith, J. T. Callaway, James M. Chandler, James Aaron

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Vickers Balanced Vane Type Pump is Engine Driven. Bulletins 36-12 and 49-52.

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Crossman, Theodore E. Dougherty, Wesley S. Erwin, Harry Edward Figgie, Jr., Milton A. Forester, Joseph Harwood, Walter J. Kingscott, Jr., Lester W. Klouser, Alexander J. Kosidio, Donald MacDonald, Gordon McCririe, Louis Muchy, Edward L. Nemetz, John A. Prokop, James C. Rhodes, Vernon E. Riddell, Earl D. Robertson, George S. Robinson, Sydney Rogers, Stanley Smolen, Kurt O. Tech, Harris C. Thomas, Homer S. Tolan, Jr., Frank C. Wade, Nicholas Wolofski.

Hawaii Section
Arthur J. Yeend.

Indiana Section
Richard K. Thelen.

Kansas City Section
William Bauman, Richard Henry Sauer.

Metropolitan Section
Andrew R. Benedictus, Robert William Eby, Paul A. Finn, Winifred J. Huebel, David Wark Hutchinson, Norman Henry Kreisman, Homer F. Malone, Ralph W. Morstad, Peter Thomas Panaccione, James L. Ryan.

Mid-Continent Section
Eulan C. Kortge.

Milwaukee Section
Edward B. Falk, Fred H. Huennekens, Charles Fredrick Mohrbacher, Carl F. Navotny, Paul Gerard Willer, Jr.

Mohawk-Hudson Group
William H. Holst.

New England Section
Norman Goodwin.

Northern California Section
Gordon S. Eaton.

Northwest Section
Ernest William Boley, Jr., William B. Royall, Floyd J. Weeks.

Oregon Section
Rowland L. Miller, Sr.

Philadelphia Section
P. H. Carstensen, Joseph Charles Dougherty, Halsey R. Jones, George S. Lamson, George Daniel Sobresky.

Pittsburgh Section
James M. Taylor.

Salt Lake Group
Darrell George Bunce.

Southern New England Section
Herman Dvorak, E. F. Zawacki.

Southern California Section
John C. Bartlett, George G. Gell, Jean Bordeaux, Jr., Burdon Louis Davidson, Robert B. Fuller.

St. Louis Section
Robert L. Burg.

Syracuse Section
David I. Dilworth, Jr.

Texas Section
Sgt. John Vincent Bassett, Jr., W. F. Kascal, J. R. Terry, Edward A. Walsh.

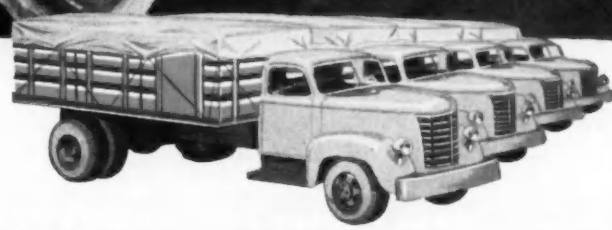
Twin City Section
Earl E. Melby.

Washington Section
William Daniel Perreault, John Melford Sanders.

Western Michigan Section
Leonard Lockwood York.

Outside of Section Territory
James Shelby Bowron, Lawrence R. Daniel, Jr., Henry G. Eichhorn, Raymond Henry Eppling, F. E. O'Callaghan, Jr., Millard Arnon Pinney, Robert J. Schroeder.

Foreign
Douglas Stuart Ralph Coltart; England.



New Members Qualified

These applicants qualified for admission to the Society between March 10, 1950 and April 10, 1950. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

Charles F. Whitmer (M).

British Columbia Group

Conrad A. Anderson (A).

Buffalo Section

James C. Scott (M).

Canadian Section

James Garvin Crichton (A), John Scott Murray (A), Wiliam James Phillips (A), Stephen M. Young (M).

Central Illinois Section

Richard Eugene Berger (J).

Chicago Section

Milton E. Connelly (A), William F. Fisher (J), James K. Gaylord (A), Russell B. Hagen (M), Edward D. Heideger (A), Harold V. Parsley (M), Bernard W. Posel (J), Philip J. Sperry (M).

Cincinnati Section

Edgar Morris Hymans (M).

Cleveland Section

Roger Owen Bay (A), Norman Hilker Brandt (J), Daniel A. Canute (J), Charles H. Cutting (J), Earl H. Simon (J), George Gene Younger (J).

Detroit Section

Rupert L. Atkin (M), Herbert W. Becker (M), Henry C. Bogle (A), Basil E. Brown (M), Vincent A. Buck (M), William A. Compton (M), Manuel P. Costa (J), Gordon P. Deneau (J), Harold Fischer (J), Terry Hudyma (J), W. R. Johnson, Jr. (M), Benjamin Stuart Kingsbury (J), Douglas T. Lewis (J), Henry C. McQueen (M), David Palmer Moore (M), Robert L. Nathan (J), James M. Porter (M), Anthony S. Ryff (M), Louis Joseph Sabatini (J), Henry F. Schebor (J), Jesse D. Sewell (M), J. Bernard Siegfried (M), James E. Vincenty (M), John H. Wilkinson, Jr. (J), Paul D. Wright (M).

Indiana Section

LeRoy V. Bradnick (M), Arthur W. Davis (J), Robert Charles Schmidt (J), Allen Randolph Stokke (J).

Metropolitan Section

Leon F. Banigan (A), John G. Lippert (J), H. Norman Nugent (A).

Mid-Continent Section

Bill Eugene Council (J), Charles E. Defabaugh (M), Barney R. Doak (J),

Clarence J. Martin (M), Jack W. Reeves (A).

Milwaukee Section

Charles Klement Alexander, Jr. (J), John Jerome (J), Carl T. Fliss (J), Norbert W. Marks (J), Charles E. Melcher (A), Robert H. Wilke (J).

Mohawk-Hudson Group

Perle E. Kezer (A), G. Robert McRobbie (A).

New England Section

Donald F. Warner (M).

Northern California Section

William Paul Bardet (J), Francis H. Bradford (M), Joseph H. Kalakian (M), Robert F. Peterson (J).

Northwest Section

Edwin Lee Johnson (J), Lloyd M. Landwehr (M), Robert G. Loser (A), Algot R. Nygren (A), Robert S. Sears (A).

Oregon Section

James R. Aaron (J), Jack C. Akers (M), Arthur Lyle Donaldson (A), Peter E. Piluso (A).

Philadelphia Section

Donaldson P. Adair (A), Clarke Leigh Bicking (M), Edward F. Harford (M), Francis L. Heist (A), Alfred Leone (SM), George A. Marshman (A), William Millar Morrison, Jr. (J).

Pittsburgh Section

Charles E. Dexter, Jr. (A), Henry J. Grance, Jr. (J), William F. McClellan (A).

Southern California Section

Klaus Walter Martens (A), Harold W. Bailey (A), Allan G. Bell (J), Floyd Thaddeus Horton, Jr. (J), L. A. Pfankuch (M), James Edward Stadler (J).

Southern New England Section

Walter A. Dommers (M), Raymond P. Lambeck (M), Vernon Victor Lucas (J).

Spokane Intermountain Section

William O. Alexander (A).

Texas Section

R. P. Akey (M), Joseph R. Shewitz (A).

Twin City Section

Harry H. Takata (J).

Virgina Section

Robert E. Hale, Jr. (A).

Washington Section

Warren W. Dewey (A), Herbert N. Johnston (J), Fernando Pessoa Rebello (FM), Philip L. Ward (M).

Western Michigan Section

Robert J. McWhirter (J).

Williamsport Group

Allen Weiss (SM).

Outside of Section Territory

James Edward Coleman (A), Roy E. Knoedler (A), Harold Edward Meunier (A), Stanley A. Reeves (A), Morris Garfield Roberts (A), O. Roger Shively (J), C. F. Van Culin (A), John Walter Wake (A).

Foreign

Richard Chaney (M), Australia.

HAVE YOU Changed Your Address?

So that your SAE mail will reach you with the least possible delay, please keep SAE Headquarters and the Secretary of your local Section or Group advised of any changes in your address. Such notices should be sent to:

1. **Society of Automotive Engineers, Inc., 29 West 39th St., New York 18. N. Y.**
2. **The Secretary or Assistant Secretary of your Section or Group at the addresses listed below:**

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Burdette Trout, Suite 6, 1436 Pendrill St., Vancouver, B. C., Can.

Buffalo

Robert W. Morgan, 32 Windover, Hamburg, N. Y.

Canadian

Frank G. King, Canadian Automotive Trade, MacLean-Hunter Publishing Co., Ltd., 481 University Ave., Toronto 2, Ont., Can.

Central Illinois

James C. Porter, 120 Isabel Ave., Peoria, Ill.

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Floyd E. Ertsman, Chicago Section, SAE, 1420 Fisher Bldg., 343 S. Dearborn St., Chicago 4.

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Fred Hedemann, 2110 A Kakela Pl., Honolulu, T.H.

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Kansas City

John P. Dranek, Box 304, Grandview, Mo.

Metropolitan

(Miss) J. A. McCormick, Society of Automotive Engineers, 29 West 39th St., New York 18, N. Y.

Mid-Continent

Delton R. Frey, 234 N. Highway, Route 2, Cushing, Okla.

Milwaukee

Charles H. Duquemin, Le Roi Co., 1706 S. 68th St., Milwaukee 14, Wis.

New England

Edward G. Moody, Ed. G. Moody & Son, Inc., Daniel Webster Highway, Box 130, Nashua, N. H.

Northern California

Morris H. Pomeroy, P. O. Box 427, Burlingame, Calif.

Northwest

Alfred P. Nelsen, Wagner Electric Corp., 1918 First Ave. S. Seattle 4,

Oregon

Edward A. Haas, 6334 N. Missouri Ave., Portland 11, Oreg.

Philadelphia

Linn Edsall, 2301 Market St., Philadelphia 3, Pa.

Pittsburgh

Warren J. Iliff, Equitable Auto Co., 214 N. Lexington Ave., Pittsburgh 8, Pa.

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Turn to p. 114

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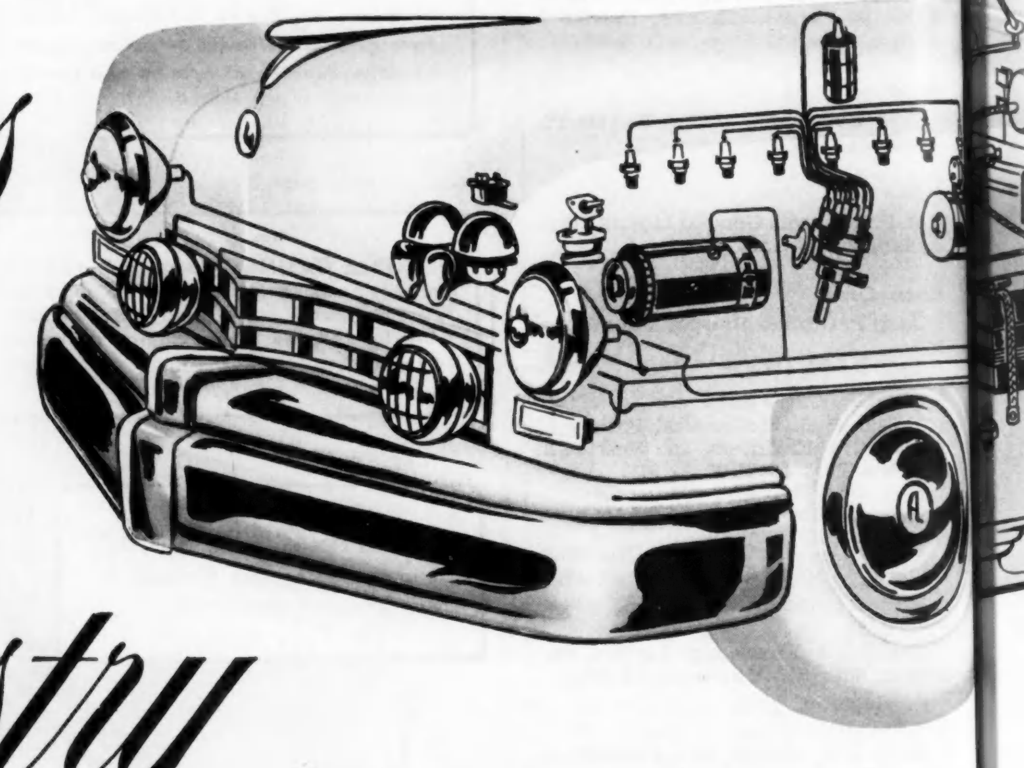

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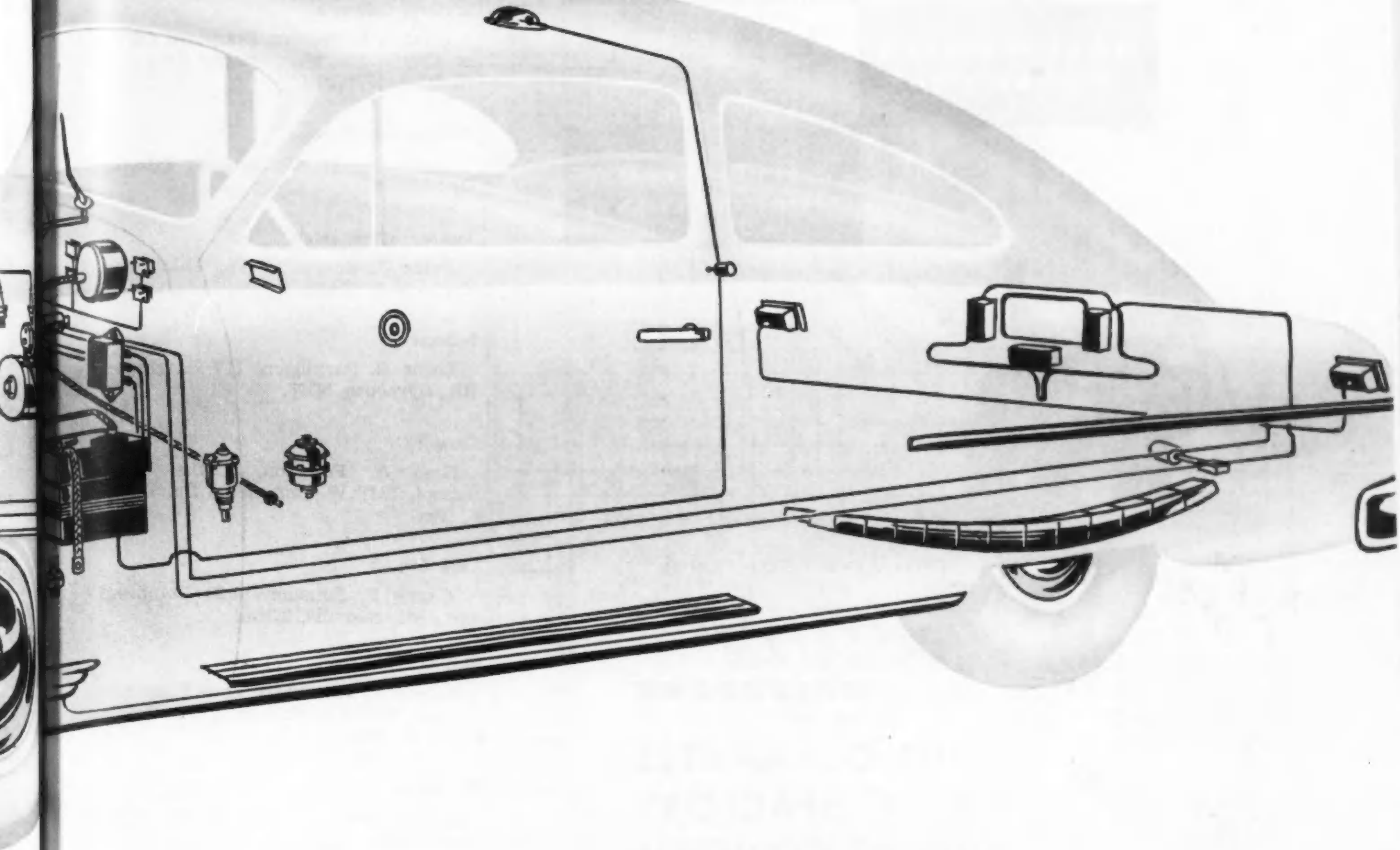

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Alexander M. Watson, 81 Foxcroft Dr., Manchester, Conn.

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Peter J. Favre, 10 W. Third Ave., Spokane 8, Wash.

Syracuse

Leslie R. Parkinson, 117 Harrington Rd., Syracuse, N. Y.

Texas

Ross A. Peterson, Texas Trade School, 1316 W. Commerce St., Dallas 8, Tex.

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Wayne E. Schober, 4620 Columbus Ave., Minneapolis, Minn.

Virginia

Robert P. Knighton, Esso Standard Oil Co., Broad & Hamilton Sts., Richmond 21, Va.

Washington

Hyman Feldman, 3222 M St., N.W., Washington, D. C.

Western Michigan

Thomas Reeves, Continental Motors Corp., Muskegon, Mich.

Wichita

Virgil W. Hackett, 143 N. Fountain. Wichita 8, Kans.

GROUPS

Atlanta

H. M. Conway, Jr., Southeastern Research Institute, Inc., 5009 Peachtree Road, Atlanta, Ga.

Colorado

Kenneth G. Custer, 1216 South Williams, Denver 10, Colo.

Mohawk-Hudson

A. Frank Geiler, Schenectady Railway Co., 121 Erie Blvd., Schenectady, N. Y.

Salt Lake

Stanley W. Stephens, 36 E. Crystal Ave., Salt Lake City 6, Utah.

Williamsport

Carroll S. Townsend, General Armature & Mfg. Co., Lock Haven, Pa.

For the Sake of Argument

Engineers and Politicians

By Norman G. Shidle

Sentences and words have weight, just like designs. Designs with excess weight use more materials, cost more to carry as parts of a vehicle. Sentences and words with excess weight are harder to lift from paper to mind. They cost more in readers' time.

Simple design is harder to do than complex. First models usually have more parts, weigh more, are harder to build than later models. When an engineer "improves" a design, he almost always simplifies it.

Same thing is true when he writes about it—or about anything else. The more simply he tells of it, the more people does he interest—and get to understand it. . . . And the more complex the design, the greater the need for simplicity in talking about it.

Engineers write like politicians more than they like to admit. Both often share a common fault. They urge wide spread of ideas in sentences which prevent widespread intake. Not uncommon are engineering counterparts of a Connecticut Senator's 11-page pamphlet to R.F.D. boxholders describing his atomic peace plan. First facts about the plan appear on page 8—and 82-syllable, 51-word sentences are not infrequent. Like this one:

> "At almost any cost we must assure that the Russian people have opportunity to consider side by side the atomic proposals of their own rulers and our atomic proposals and that the Russian people act as part of the world jury, which brings in a verdict covering this monumental issue."

Yet many ways to simplify the "design" are at hand. One, which cuts syllables 33% and words 13%, is:

> "The cost doesn't matter. We must make sure the Russian people get a chance to weigh our atomic proposals side by side with those of their own rulers. They must be a part of the world jury which gives a verdict on this grave issue."

Short words for long, marching instead of dragging sentences might have cut the Senator's pamphlet to seven pages. He might permit readers to lift one-third less sheer weight of words to get the same number of ideas and facts.

Engineers or voters, more men will read one line than three. More will read seven pages than 11. The more facts or ideas to be given, the more reason to package them in light-weight, living words and sentences.